JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

VOL. 20 DECEMBER, 1928 No. 6

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JOURNAL
OF THE
AMERICAN WATER WORKS ASSOCIATION

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Discussion of all papers is invited

VOL. 20 DECEMBER, 1928 No. 6

UNIFORM ACCOUNTING FOR WATER WORKS[1]

BY R. B. F. CHISHOLM[2]

I have been asked by Mr. McDonald, Chairman of the Plant Management and Operation Division, to prepare for presentation to this Association a paper on Uniform Accounting for Water Works; but before going into this subject, might I suggest to your Association, the advisability of appointing a committee or committees to undertake the formation of an Accounting Section similar to that of the National Electric Light Association, or at least work in conjunction with the N. E. L. A.

I am thoroughly convinced that considerable benefit would accrue to all members of the Association whether they represent large utilities or single operating units. It is obvious that the electric and gas utilities have made much more progress in this direction than have the water utilities and an organization of this character would be of considerable help in bringing all commissions in line on national uniform accounting classifications, which, of course, is most desirable. It would also be possible to secure the benefit of the electric and gas associations' experience in this connection to a much greater extent than by individual effort. The Association would also benefit by increased membership and revenues, as most water utilities, I feel sure, would wish to be represented in this Section.

[1] Presented before the Plant Management and Operation Division, the San Francisco Convention, June 10, 1928.

[2] Secretary, California Water Service Company, San Francisco, Calif.

In order to proceed along some definite lines, we will start by considering what the term "Accounting" means.

I. DEFINITION

Accounting may be defined generally as a procedure relating to the assembly and recording of facts in business transactions in an orderly, chronological manner, so that periodical statements may be rendered, showing the financial position of any business enterprise and the results from operation. It may be considered as the right hand of management or administration.

Accounting embraces a large field:

a. General Accounting
b. Plant Accounting
c. Cost Accounting
d. Stores Accounting
e. Revenue Accounting
f. Budgeting
g. Accounting Systems
h. Systems of Internal Check
i. Statistical Information
j. Payroll Accounting
k. Expense Accounting
l. Accounting for Capital Stock and Dividends, etc.

Accounting is based on theory as well as fact. Theories or mental speculations, as they may be called, after having been tested by long usage, have become established as principles, which in the accounting field become known as principles of accounting. However, accounting principles are subject to development, evolution and change, so that principles laid down in the past must not be considered as ironclad, but as subject to continuous improvement. Each and every business problem must be solved by the accountant, not on the basis of an accounting formula, not on the basis of precedents relating to methods adopted by others, but on that of the conditions prevailing and of the objectives to be accomplished in each case.

When we speak then of uniform accounting for our own field, we must keep the above thoughts in mind and realize that often local conditions, local policies, etc. must be considered and to some extent may require modifications of any principles of uniform accounting which we may endeavor to lay down at this or any other time.

II. UNIFORM ACCOUNTING

Uniform accounting for water utilities can best be expressed through uniform classifications of accounts, but uniform classifications of accounts do not necessarily result in uniform accounting as different accountants may classify items under entirely different heads. For example:

a. Overhead expense, such as salaries of officials, general management and supervisory costs are absorbed by some companies entirely in expense, while others allocate them on a basis of construction and operating expense. Accurate application of these expenses is very essential so that neither construction nor operation will be burdened unduly.

Where a utility charges a large part of its overhead to construction, the fixed capital account is, of course, increased and the operating expenses are reduced to a minimum. Such a practice might result in a reduction of rates by public utility commissions. On the other hand, if operations are charged with a large overhead, which should apply to construction, then the commission would probably allow a very small overhead on the property with the result that a large return may be earned on less than its true cost. Utility companies should endeavor to allocate these overheads to both construction and operation on the basis of actual work performed. This would also apply where a utility handles gas and electricity or water, the over-head costs being distributed on as nearly an equitable basis as possible to the actual cost of each department.

This procedure, as we all know, is on the basis that even though, aside from the importance of having records prepared and kept correctly, it is preferable to earn on expenditures over a long period of years that should be capitalized rather than getting such items allowed as expenses for that particular year only.

The wages of construction foremen and other supervision of labor should be handled as direct labor costs and not included in the overhead expense. It is desirable that the accounting policy in connection with the cost of engineering and general supervision work for construction should be followed as closely as possible with the practices of valuation engineers in setting out the cost of engineering and supervision, apart from the unit cost of labor and materials charged directly.

Construction should also be charged with reasonable proportion of legal expenses, compensation insurance, public liability insurance,

taxes, and also interest on the money expended during the period of construction. Various methods are in use in determining these ratios and some utilities consider these items as direct charges, while others include them in overhead.

b. Indirect expenses such as purchasing, stores, etc., may be absorbed in the case of overhead expense in operation or allocated properly to construction and operation.

We consider that the cost of purchasing supplies, handling of stores and small items of freight and hauling are properly chargeable to the unit of cost of the material. It appears to me that the most logical way to handle these expenses is to allocate them on the basis of the cost of materials used on construction and operation. Some companies follow the practice of charging out materials at the actual cost as shown by the stock cards, but I believe that the simpler method of withdrawing materials from stock is to use the average cost system.

c. Minor replacements or repairs are absorbed by some companies entirely in expense and by others absorbed partially, at least, in depreciation reserve. We have followed the policy in the case of replacements of retiring the original capital in full and making the proper entries to depreciation reserve, the cost of removing being charged to operation.

One matter which has been discussed to a considerable extent by the officials of our company is that of paving over mains, which necessitates the raising or lowering of mains, which is ordered by a municipality, but for which the company has to stand the expense. Many utilities charge the entire cost of this work to operation even though the location of the mains may be changed; but we have followed the policy of retiring from capital the original cost of labor and material laying these mains, making the proper entries to depreciation reserve and charging into capital the cost of opening up the ditch, back-filling and paving. Where the material was retired at a salvage value, this same value would be charged back to capital, when used in connection with construction.

d. Officers' salaries are classified by some companies in general expense, while others allocate them to the various classified superintendence accounts. We have considered them as general expense, but distributed over our districts on the basis of gross revenue.

Any differences such as above would, of course, make comparison between various companies of little use.

III. DESIRABILITY OF UNIFORM ACCOUNTING

Uniform accounting classifications and procedures, in spite of the above-mentioned difficulties, are undoubtedly desirable, at least as an ideal to strive towards for the following reasons:

a. Permits comparisons of financial position, operating results, etc. to be readily made between water companies.

b. Results in application of Federal Income Tax on a uniform basis between all companies.

c. Valuable to the investor in water companies securities, as financial statements prepared for circulars would be prepared on the same basis. In other words, the investor would be furnished with net earnings statements, etc. based substantially on the same accounting procedures, so that he could rely on the statement of earning capacity in relation to interest or dividend charges as being comparable between water companies all over the country.

d. Valuable to the consumer, as he could be brought to realize that there would be less opportunity for discrimination in rates between water users of different communities due to the fact that the basis for ascertaining the return on the rate base would be similar.

e. Advantages to regulatory bodies. Most utility commissions have been given the regulation and control of utilities operations and many commissions require utility companies to keep their accounts and records in a manner prescribed by them. This control is exercised largely through accounting records, reports and procedures and these commissions are dependent to a great extent on the soundness of the accounting principles of companies under their jurisdiction.

IV. PROBLEMS TO BE CONSIDERED

Adoption of a uniform classification of accounts by State Public Utility Commissions throughout the country is desirable. The National Association of Railway and Utilities Commissioners have provided a uniform classification of accounts which was revised November, 1922, and goes into the matter of utility accounting in a very comprehensive manner. Up to 1925 a total of 25 states have adopted completely, or nearly so, this uniform classification. Nine commissions have no jurisdiction over this accounting; one has adopted the Federal Power Commission's classification and twelve more have the classification under consideration.

V. VALUE OF UNIFORM CLASSIFICATION OF ACCOUNTS

One of the principal advantages of uniform accounting is that proper comparisons could be made in financial statements. Where a holding company has interests in many states, it is evident that a uniform classification is desirable. The California Water Service Company reports to the Federal Water Service Corporation of New York under the National Association of Railway and Utilities Classification, while our accounts and records are carried under the California classification of accounts as prescribed by the Commission. If the California Commission could be persuaded to adopt the National Association Classification, it would, of course, result in considerable saving to our company.

VI. CENTRALIZED ACCOUNTING

This is a matter that should be considered very seriously by public utilities. As an example, I shall briefly state the system which our company has adopted in this regard. We are operating twenty-two companies in California and by adoption of centralized accounting, we are enabled properly to classify accounts, to employ less expensive help in the outside districts, close our books earlier, and for the purpose of auditing or investigation by utility commissions, all original records remain in the General Office. This means that the General Office receives daily all Time Cards, Withdrawals of Stores Tags, Auto Mileage Reports, Bank Deposits, etc. As these reports are received, by the General Office, they are checked and tabulated and at the end of the month we have only one or two days reports to enter.

In a large organization or even in organizations consisting of more than two or three separate properties, proper accounting control is absolutely essential for efficient and economical management.

Another feature of centralized accounting is the matter of employing specialized help. It has been proven that specialization in every case gives greater efficiency at a reduced cost.

Under the system of employing an accountant in each company or district, we have found that the interpretation of accounts differed to such an extent that departmental costs were entirely out of proportion. For instance, some accountants might consider rent, stationery and printing in the commercial department as a general expense, while others would consider it as a part of the commercial

department. Centralized accounting eliminates these descrepancies and gives us a true analysis of these expenses over the various districts and the management is thereby enabled to place its finger on the companies or districts which are not operating efficiently.

The problem of educating the man in the field is extremely difficult, but with the adoption of centralized accounting and the use of accountants specialized in the study of classifications, we have eliminated our trouble in this respect.

VII. CONSUMERS BILLING

A great deal has been said as to the successful operation of the stub system of billing, but I believe that the stub system has been developed to such an extent that there is no longer any doubt in the minds of large utilities but that it is the most economical and successful method. Our company is preparing at the present time to adopt a stub plan, using a government post card for mailing to the consumers. This alone reduces the postage to one-half, besides saving in the purchasing of envelopes. We have approximately 85,000 consumers and in postage, labor stuffing envelopes and the cost of envelopes themselves, we expect to save $20,000.00 per year.

VIII. STORES ACCOUNTING

The method of handling the Stores Department varies considerably in utility companies, but proper stores accounting is essential to adequate control of material and supplies.

A definite assignment of responsibilities for stores accounting activities is, of course, necessary if proper control is to be obtained. This is a very large subject and it appears to me that a uniform method of handling stores would be of very great benefit to public utilities.

We have adopted centralized stores accounting. We are thereby enabled, from the General Office, to analyze the quantities of materials and supplies on hand at any station, transfer any overstock from one station to another, keep accurate records of obsolete materials or junk, check up on slow moving material and see that proper credits are made to plant in the case of retirements.

We use accounting machines in this department and all pricing, posting of materials and withdrawals from stock, figuring average costs and balancing is done on two machines for twenty-two companies.

IX. MACHINE BOOKKEEPING

The introduction of bookkeeping machines into general accounting has, I believe, made very satisfactory progress, especially where the company has a large volume of calculations and the work can be concentrated into the hands of one or two machine operators, the result being that production will be higher and the unit cost much lower. This will also leave the more expensive help to carry out more important duties.

I have seen the bookkeeping machines used on public utility general ledger work, journalizing, cash books, daily cash statements, bank registers, capital stock records, stock sold on the installment plan and payroll work. The important result of machine operation is that the books of account are in balance at all times and the matter of taking off a trial balance is very simple.

X. DEPRECIATION

The matter of depreciation of plant should be considered very fully by the Association for the reason that there is no uniform method. At the present time, it is impossible to lay down any specific rates of depreciation which will have any absolute value for conditions under which equipment is used varies so much that no uniform rate could reasonably be determined for all utilities.

When we consider the number of methods used, i.e., annual apportionment of depreciation, straight line method, depreciation after percentage of diminishing value, annuity method and sinking fund basis, it is obvious that a uniform system would be of great advantage. It must be remembered, however, that there are advantages and disadvantages in any system, and while the straight line method is more generally used on account of its simplicity, it may be conceded that the sinking fund method is the better. This system, however, is expensive, and would necessarily mean that uniform lives would have to be allotted to the various classes of fixed capital and very complete plant records set up, so that in retiring capital, the proper life of the plant involved could be determined.

It should also be borne in mind that in adjusting rates, most utility commissions go into the matter of depreciation very fully and many utilities have had to appropriate considerable money from their surplus to make up the depreciation reserve which the commission considered necessary.

In addition to the loss from wear and tear, equipment is subject to further depreciation from economic changes. Experience may show that on the average, certain equipment would be serviceable for twenty years, but becomes obsolete in one-half that time on account of new inventions. Although the equipment itself might be in very fair condition, it would probably pay the utility to replace it with the improved type. A definite allowance, therefore, should be made for obsolessence and such an allowance will be recognized by the Internal Revenue Department.

XI. COST ACCOUNTING

This is a subject that has not received a great deal of consideration from most utilities, but I believe that utilities are coming to realize the importance of keeping adequate cost records.

The principles and practices of cost accounting must be adopted to the utility business in order that companies may analyze their construction costs and properly record them in fixed capital accounts. The management should also be advised as to what construction work is costing and this can only be done with adequate cost records.

This Association could coöperate with the National Association of Cost Accountants towards the adoption of some uniform system.

XII. BUDGETING

It is very important that utilities provide adequate budget control, not only for capital expenditures, but also maintenance and operating expense so that the proper coördination be maintained between the amount of capital going into industry and the use of such capital in construction programs.

In the utility business a budget is essential as a statement of future operating and extension plans, financial program, summary of appropriations and a standard for the measurement of performance.

XIII. PURPOSES OF THE BUDGET

1. To define executive policies as to future operations.
2. To promote coöperation in the execution of policies and plans.
3. To prescribe the limits within which expenditures are to be confined.
4. To determine what funds will be required and when, so that they may be provided in a reasonable and orderly manner and at a minimum cost.

5. To set up standards by which accomplishment may be judged.

The companies using budgets most successfully are those in which the line and staff have had their part in the preparation of the estimates necessary for the construction of the budget. Since budgets set forth a complete plan, every division of the company should be represented in the preparation of the estimates.

The preparation of a budget should be under the direction of an officer of the company who is intimately familiar with the affairs of the company and of utility operations in general. He should understand accounting, financial and operating problems thoroughly and be familiar with the functions of all the departments of the business.

The accounting staff is the logical one to handle the accumulation of budget data, since they are the most familiar with the cost of previous operations of the company. As a budget must be based on the operations of the past, it is desirable that the accumulation of these data be placed in the hands of those who are most familiar with it.

The preparation of a budget should be in considerable detail and given a specific number so that when the approval is given for expenditure of money, a reference can be made to the budget number and the final cost of the work for expenditure involved should tie in closely with the figure on the budget. For example, we might have an item in the budget for the building of a reservoir which would bear a certain budget number and when the authorization is given for the actual expenditure of the money, the budget reference should be shown on the authorization, so that when the work is finally completed, a check can be made against the estimated cost.

This is another phase of the business which would benefit greatly by uniform accounting.

In conclusion, I wish to say that each of the matters touched upon in this paper is a study in itself. Our Association would benefit greatly by going into uniform accounting very fully, for some of the greatest reductions in operating expenses are made possible by the comparative information made available through the scientific accounting preparation of operating results. Uniform accounting is, of course, essential for such comparison.

HYDRANTS AND VALVES[1]

By J. I. Prugh[2]

Sacramento is the answer to the water superintendent's dream of heaven. Those who do not know Sacramento probably will think this a rather broad assertion, but I am not boosting, boasting or bragging—merely stating a fact.

First, we have no frost line. This necessitates a bury sufficient only to protect the mains from traffic. Second, Sacramento was at one time a lake. Consequently, all ingredients affecting cast iron or steel pipe have been leached out and we have no external corrosion. Last, but not least, the greatest variation of head against which we pump will not exceed 15 feet. I mention those items just to justify my first statement.

I am a strong believer in good valves and lots of them. I do not mean ample or sufficient. I mean lots, so that when a line is killed the users of water inconvenienced will be reduced to a minimum.

In Sacramento the valves from 4- to 10-inch are on an average 330 feet apart; from 12- to 42-inch, 750 feet apart. That means that when two distributing lines intersect we have 4 valves; when a distributing line and a trunk line intersect, 3 valves; and when two trunk lines intersect, 4 valves. In that way, when we have to kill a main we can by-pass in nearly every direction. Thus, only a small area is ever without water.

Due to our shallow bury we have adopted the method of protecting our valves from traffic. This method is employed on valves up to 14-inch. Above that we put them in vaults. Somebody said they used manholes. We have one street with 9 manholes and if anybody tried to put in any more there would not be any street left.

Usually a granite curb is buried in the ground and extended about 4 inches above the body of the valve. Across these are laid two pieces of light railroad rail, and on top of this is set the box which is a piece

[1] Presented before the Superintendents' Round Table Discussion, the San Francisco Convention, June 11, 1928.

[2] Superintendent, Division of Water, Sacramento, Calif.

of 8 inch cast iron pipe extending to the surface. Into this piece of pipe the drop plug is set so that any blow transmits itself to the railroad rail and into the rocks without damage to valves.

During the last five years only 15 valves have been repaired, and none of this type. Whenever we have valve leaks, or whenever we put in new valves, this type of construction is used.

So far I have been able to steal my granite blocks from the street department and my railroad rails from the highway, so it has not cost much to date.

In regard to hydrants, we try to follow out the recommendations of the National Board of Fire Underwriters. We have adopted as our practice a 6-inch lead from the main to the hydrant, the hydrant having a steamer connection and two hose outlets. Most of our hydrants are so equipped, and I am gradually, from time to time, replacing the old ones with the new type. It is rather hard because there are some 4-inch mains and some 4-inch leads, but we hope eventually to comply with all the under-writers' requests.

The hydrants are placed on 600 foot centers. We place them on the corner so they can serve four ways. If Mr. Volstead's Act is not better observed in the future, I will have to put some hinges on them. Otherwise the malefactors will climb over them and knock them down.

There was one peculiar hydrant in Sacramento. It consisted of a 4-inch barrel with a nozzle, a hose nozzle outlet. Around that was an 8-inch space. This space was stuffed with straw to prevent freezing. I do not know who was the authority who bought the hydrant. I do not know who manufactured it and furnished it to the city. But I do know this, whoever wished those on to Sacramento was *some* salesman!

DISCUSSION

CHAIRMAN MACDONALD: Would not that mode of packing permit removing the spindle?

MR. PRUGH: Hardly. You would have to take out a little cement for street improvement.

CHAIRMAN MACDONALD: Gentlemen, this is a very interesting subject. Mr. Prugh presented his case in a very short and concise

manner. I am sure we have other means of construction which are equally interesting. We should like to hear from some of the men in the northern cities where the mains are of considerably lower depth than in Sacramento. Is there anybody here from Minneapolis or Saint Paul?

We use a type in Northern Canada, in Ottawa, that has a barrel on the outside of the hydrant. The purpose is to hold back the earth around the hydrant. Then when frost takes place there is a movement upwards and the ground adheres to the barrel. The barrel slides up 2 or 3 inches and does not cause movement of the inner casing proper. That is a common occurrence.

The outer barrel also permits the removal of that hydrant from service in the ground without any changes. Would it be that type of hydrant?

MR. PRUGH: The smaller barrel sits in a flange, with the flange on the outside. They are both together. But the lowest temperature, I think, that was reached in Sacramento was 29. So the hydrants have been very effective.

WILLIAM LUSCOMBE: (Gary Heat, Light and Water Company, Gary, Ind.): Speaking of valves, I think that it is a very important thing for any water system in specifying to have all valves open or closed, as the case may be, in a certain direction to avoid any confusion. It often happens that a valve is supposed to be open when it is closed.

I have known of a good many engineers who stated that, when they made an investigation of poor pressures in the cities and towns mentioned, they found instead of having to reinforce by putting in mains, all that was necessary was to make a thorough inspection of valves in the distribution system and have them opened. That often brought about the remedy.

I should like to ask what Mr. Prugh finds is the most satisfactory way of opening the larger gauge with the power equipment.

MR. PRUGH: Ninety-nine per cent of our valves open by turning to the right. Those that do not have to have the plate taken off to get to the screws. There is a red piece of tin in there. On that is marked "L," which means it is a left-hand valve. That has got to go back after the valve is operated. Sometimes you cannot always

get the same kind of valve. The other day I had to have a 14-inch valve; so I got a left-hand valve.

CHAIRMAN MACDONALD: Does that answer your question?

MR. LUSCOMBE: What I was interested in finding out was, by what mechanical method are the larger size valves opened?

MR. PRUGH: Sometimes with an air hammer. You crack them and then do it by hand. Some are opened electrically. Those valves open by turning to the right.

CHAIRMAN MACDONALD: You do not use gasoline motor power for operating the valves?

MR. PRUGH: No.

CHAIRMAN MACDONALD: Was that what you had reference to?

MR. LUSCOMBE: Yes, sir.

CHAIRMAN MACDONALD: We should like to hear from those who have used automotive power in using great valves and what success they have had. Are there any gentlemen in the room using in their cities gasoline power for valves? If so, will they let us have their experience? It is unfortunate Mr. Brush is not here. His city is fully equipped with operating devices.

We in our city have one truck only equipped for emergency use for the operation of valves located in the streets. It is necessary to install all valves with a minimum covering of 7 feet, to safeguard against freezing. I am speaking of the City of Ottawa.

We have very few valves in the system that are not opened clockwise, or to the right. We started four years ago. At that time we had some 78 valves in the city which opened contrary to clockwise. Each summer we have reduced these by installing, manufacturing and inserting new spindles and operating nuts of stainless steel. We are replacing all spindles in Ottawa with stainless steel. We have found this type of spindle to be the most acceptable of any we have used.

We do not have an indicating plate showing which valves open to

the right. But, by the end of this summer, all of the valves will be changed to valves opening clockwise.

As to the method used for operating these valves, I would say that we have a large service truck equipped with proper gear ratio device, manufactured by one of the well known firms making valve closing devices. This is mounted about midway in the chassis of the truck. We have a record now of every valve in the city with regard to its size, the type of valve, and the number of revolutions required to close it.

This information is carried by the operator in charge of the truck, and each sheet contains the exact information for every intersection in the city, on a scale 20 feet to the inch.

In addition to that, in the wintertime, during a break or rupture to the system, some of these valves are under more than 24 inches of ice. It would be rather difficult to locate these valves if we had not ready means of doing it. We have given the matter considerable attention.

While I find that these records are of certain benefit, yet the erection of 6 bronze plates on intersection buildings and telegraph poles, street or railroad poles, has been of vast help to us. These bronze plates are all erected at a standard height of 7 feet above the elevation of the curb and they give the information stamped on the bronze plate: the size of the valve, together with the number of feet and inches that the valve may be found from the surface or the base of the pole.

All our trucks serve as emergency trucks and carry tapes and other instruments to make these valves more readily accessable.

Are there any other questions?

A MEMBER: May I ask on how large a valve you use automotive power?

CHAIRMAN MACDONALD: Twelve inches and up.

A MEMBER: What pressure?

CHAIRMAN MACDONALD: We do not have to use it, but we find it is an advantage to use it on the 12-inch. We have valves running up to 48 inches. We find we can speed things up by using gasoline power.

MR. PRUGH: I find we have had no trouble with 36-inch valves.

CHAIRMAN MACDONALD: It is a matter of time with us. When we get a rupture to the service to the main, it will take probably twenty minutes to open it by hand; or, at least, so our experience shows. It takes that length of time to operate a 36- to 42-inch valve. With power device you can cut down that time to from three to five minutes, without creating any danger to your system.

I have known of instances in our system where it has taken thirty-eight minutes for three men to close a 42-inch valve, operating by hand. We can cut that down to five or six minutes by power.

A. ERVAST (Coronado Water Co., San Diego, Calif.): What is the size of your inscription plate?

CHAIRMAN MACDONALD: The plates are 3½ x 2½ inches.

MR. ERVAST: What arrangements do you make with the proprietors of the telephone, telegraph and electric companies?

CHAIRMAN MACDONALD: We installed the plates some six years ago. Before attempting to do that we got in touch with the public utility and the private companies, asking them for that authority and we did not have one objection raised.

MR. ERVAST: Is your right established by ordinance?

CHAIRMAN MACDONALD: It has not been found necessary.

MR. ERVAST: Is it an individual agreement?

CHAIRMAN MACDONALD: Yes, it is an individual agreement. I should be very pleased to send you a sample plate and any other information I can give you on it that would be of help.

MR. ERVAST: Thank you.

H. W. SCHUCK (Water Supply, Burlingame, Calif.): Do you understand the standard valve opens to the right? Is that what I understood you to say?

CHAIRMAN MACDONALD: Yes, unfortunately 98 per cent on our mains open to the right.

MR. SCHUCK: Is that considered the standard? I thought the standard was to the left.

CHAIRMAN MACDONALD: Yes, the standard is open to the left. The majority of cities in Canada open to the left. However, we were unfortunately favored with a majority of valves that opened to the right, and less than 2 per cent opened the other way; so we proceeded to change those valves to the right.

A. U. SANDERSON (Toronto Filtration Plant, Toronto, Can.): In Toronto all the valves open by turning to the right, but all the valves in the stations on the power system open by turning the opposite direction, so that there is one standard for outside and one for inside.

In connection with the operation of valves by automotive power, we find it saves considerable time and labor by using this power for opening and closing the large valves in the system. However, great care is taken in closing these valves to close the last few turns by hand because water hammer develops considerable shock. Before this was done, cracks and breaks in the large mains did occur by closing the large valves too quickly.

W. A. KUNIGK (Water Works, Tacoma, Wash.): In Tacoma all the valves are on the property lines. Since we have a great many in our territory, it would be rather difficult to find the plates. At least, as difficult to find the plates as the valves themselves. We know they are located in the property lines.

CHAIRMAN MACDONALD: I just wish to point out the situation in a northern climate where the ground is covered with several feet of snow. Again, it is very difficult in the case of vacant property actually to locate street lines. They also become covered and nobody but a surveyor or someone like that would be able to locate them.

With regard to the use of these location plates, all drivers of trucks carry one or more hand flashlights. In addition to the hand flashlights we carry two or more flood lights, one on either side of the truck. These are connected separately to two 6-volt storage batteries. These batteries are portable and as soon as the trucks are stopped the lights are accessible for the work at hand.

MR. LUSCOMBE: I should like very much to have your opinion on this question. Since automobiles are coming so generally into use,

what seems to be the better location for fire hydrants to avoid damage on account of automobiles.

CHAIRMAN MACDONALD: Would you like to answer that, Mr. Prugh?

MR. PRUGH: It is a hard question to answer. We have one on a boulevard and it trembles when an automobile goes by. So I put two big rocks on the side and two railroad rails. The other evening somebody made away with the rocks and rails and got the hydrant. If you put these hydrants anywhere near a street the automobiles will get them. The safest place to put them is on the second story of a building. But there is really no safe place.

E. ORTON (Water Department, Ventura, Calif.): I want to state that in the outlying districts in our city we had some hydrants right near the curbstone. Some one came to me one morning and said that some wild automobilist had broken it. I thought I would get the fellow, who wanted to negotiate that hydrant. So we got some railroad iron, as this other gentleman had. We put rails all around it. It was not long before those rails were bent over in the direction of the hydrant. I later heard that a Ford car had stopped about a mile and a half from the hydrant with a busted tire.

MR. PRUGH: I should like to get a type of hydrant that you cannot knock down, will not break down and which will not leak.

CHAIRMAN MACDONALD: One of those hydrants with a hinge?

C. A. TRUMAN (Northfield Land and Water Company, Colorado Springs, Colo.): I should like to ask who pays for hydrants outside the incorporated limits of a community? Who pays for the hydrants and their installation?

CHAIRMAN MACDONALD: That, to me, is a question which requires a local knowledge of affairs in connection with your community. That point is coming up Friday morning in connection with one of the questions in the questionnaire.

H. K. BURTON (Water Department, Salt Lake City, Utah): In regard to hydrants outside the city, we are securing water from a

great many sources which have been opened by farming communities outside the city limits. We are now furnishing suitable irrigation to those communities; taking this water in exchange for this distribution mains have been established for these communities and provision is made in this particular case where the people can install hydrants on those lines at their expense. That is one case where hydrants have been established outside the city.

CHAIRMAN MACDONALD: I should like to ask the gentlemen present what has been the general trend of experience with regard to the breaking or twisting off of spindles in the operation of valves through skilled or unskilled men? Have you had much trouble, Mr. Prugh?

MR. PRUGH: Only once in fifteen years' experience. This was a left-hand valve and the fellow did not know about it and twisted it off. Just once!

CHAIRMAN MACDONALD: I am sure that there are a great many communities that have more than that amount of trouble. I should like to know what methods are observed in overcoming this difficulty.

Has anybody any experience in the use of stainless steel for spindles in operating nuts?

H. W. SCHUCK (Water Department, Burlingame, Calif.): How does that affect the cost?

CHAIRMAN MACDONALD: Between 8 and 10 per cent. But we find the results more than justify the additional expense. As a result, we are getting better results from the use of stainless steel, especially in our larger valves.

L. M. GRANT (Water Department, Seattle, Wash.): In connection with the operation of large, electrically operated, gate valves, we had considerable trouble with the material we formerly used in spindles. Since installing the stainless steel we have never had one valve give trouble.

INTERSTATE RIVER COMPACTS AND THEIR PLACE IN WATER UTILIZATION[1]

By Delph E. Carpenter[2]

Our nation is yet young. Definition of the respective powers of the nation and of the states is still in a state of flux. Our internal development has required solution of many conflicts between state and national jurisdictions, but we have solved only those problems which were pressing and have taken little thought of those yet to come. We have been too busy subduing the wilderness, reclaiming the desert and traversing our continent to give immediate concern to problems which may be passed on to future generations. Our states have been so engrossed with immediate necessities of growing communities, upbuilding of state institutions, formulating necessary rules of conduct to conform to our rapidly changing civilization, and with administering the internal affairs of each state, that the rapidly changing official personnel has given but passing consideration to the ultimate and external influence of internal developments or of the injurious effect of external developments upon the internal affairs and general welfare of the state. Even where such matters have been brought to the attention of state officials, more immediate demands have caused them to defer such matters to the keeping and concern of future generations or, improperly, to the control of federal agencies with limited surrender of state sovereignty.

Likewise with our rivers. Nature placed them where they are and we have used their waters as we have found them. Each state, very properly, has regarded its rivers as a part of its territory and as its great natural resource for the benefit and well being of the state and its people, and for use as the state may elect, save for national control of interstate and foreign commerce in conformity with the Constitution. Out of sheer necessity, each state has used, consumed or polluted the waters of the streams within its territory, to

[1] Presented before the San Francisco Convention, June 15, 1928.

[2] Interstate Rivers Commissioner for Colorado, Greeley, Colorado.

satisfy the ever increasing demands of its people, and, while a few conflicts have become acute, as between Kansas and Colorado, or Missouri and Illinois, in the main, state officials have been called upon to give little attention to the effect of activities in one state upon the quantity or quality of flow of the same stream within the territory of a neighboring state or states. Even where the situation has become acute, termination of official tenure has set for naught any contemplated activities.

Rivers are the fountain source from which both man and beast derive that natural element imperative to their very existence. Likewise, rivers are the carriers of all the mineral, plant and animal wastes of their drainage basins. Plants, animals and men must all drink of waters which carry the sewage of the territory. Artificial uses and interferences with the natural flow either improve or impair the quantity or quality of the water. Changes wrought by the works of man in the upper part of a drainage area may prove a blessing or a curse to those below. Diversion, storage, or use of waters within the upper territory may equalize the otherwise erratic flow for the benefit of those below and without cost to them. Use in a given part of the drainage area may facilitate or prevent uses in other parts, according to the location and physical conditions surrounding the first use.

Self defense is the first law of man and nations. Man must have water or he will perish. Without water, man cannot exist nor states endure. Differences in necessity create natural differences in preference of rights to the use of the same natural element. The necessities may differ within the same drainage basin because of differences in climate, soil, and other natural conditions. Wasteful and extravagant use of waters for the mere floating of the boats of commerce along the lower reaches of a stream should give way to more imperative demands for domestic, agricultural and power uses within the territory where the waters originate. If need be, uses by the irrigator must yield to the more imperative demands of cities diverting potable water for their inhabitants, and the power plant must stand idle to supply water for domestic and irrigation purposes. If either use must suffer, that one should be first to suffer whose necessities are of the lowest order. In time of shortage both uses cannot be supplied. He whose necessity is least must give way to him whose necessity is greater.

Natural preferences in the use of water vary with each stream

system and with each locality. While ordinarily power uses should be subordinated to domestic and irrigation demands, the location of the power plant and the periods of use of water may avoid all conflict and constitute a benefit to the uses below. The same water which returns from the irrigation of fields above may constitute a satisfactory domestic supply for cities. Raw sewage may be made ultimately potable by systems of treatment and dilution, and more than one municipal use may be made of the same particles of water. Water otherwise unfit may be treated and made the breeding ground of fishes. The varying conditions all require careful study and treatment by those resident within the territory involved.

PRINCIPLES OF ALLOCATION

The multitude of local river problems have been met and solved by the people of each state as occasion demanded. Each passing solution has established a precedent and given rise to a local custom, law or court decision applicable within the state, and these are the foundation of the rights of citizens to the use of the state resource, the waters of the stream. These usufructuary titles are held subject always to the dominant will of the state and vary with the states. In any event, by exercise of eminent domain, the state may readjust uses of water to conform to the growing and ever changing necessities of the state and its people.

But most of our rivers are interstate, and problems which are easy and simple of solution within a state present a different aspect when viewed from the standpoint of interstate relations. A state may provide that its citizens may use the waters of its streams under rules of prior appropriation, by which the first user is protected as against all subsequent users for the same purpose. Such a provision is but a rule of local administration by which the sovereign state provides an orderly system for uses of its limited water supply in a manner best calculated to benefit the state. But, for a first appropriator in a lower state to lay claim to all or a large part of the waters of a stream having its source in an upper state, is to assert a claim of foreign servitude upon the territory of the upper state without its consent and for the exclusive benefit of the lower state. For a lower state, through its citizen, thus to reach out and lay hold of the natural resource of an upper state, regardless of its necessities, would be equivalent to a permanent occupation of the territory of the upper state to its perpetual injury or destruction. Such a claim for power pur-

poses, if enforced, would not only preclude the upper state from making subsequent power uses of the same water within her territory, but would prevent further diversions for domestic, irrigation and other uses of a higher order, and would *subject* the future development of the upper state to the dominant will of the lower. The stream has its sources within the upper state and should constitute her most valued resource. Without the use of its precious waters, she cannot maintain her place in the family of states. If denied the use of such waters, her people must hunger while the people of the lower state grow fat by use of the waters rightly belonging to the upper state, and which, were it not for the dominance of the foreign servitude, could be used for the sustenance of her people and the upbuilding of her institutions.

Still another angle. Water diverted and consumed for domestic or irrigation purposes within an upper state in conformity with its laws, cannot serve the riparian demands of land owners along the same stream in a lower state. While the riparian law breeds most wasteful and extravagant methods of use because it had its origin in the humid region where drainage is a first consideration and the law is applicable to conditions there obtaining, the degree to which an upper state may exhaust a common water supply may well become a matter of interstate conflict. The situation becomes more acute where both states recognize the law of prior appropriation for local administration of uses of water within each state and where the uses by the upper state are said to infringe upon the established rights of the lower state. Failure of the lower state to store the excess flow compounds the difficulty. While rivers are the natural resource of the territory which they drain, unreasonable pollution of the common water supply by an upper state to the detriment of a lower state, may well become an issue of vital importance. These examples are but a few out of the multitude of troubles which sooner or later will confront the states for solution, but they illustrate the fundamental fact that uses which are lawful, necessary and imperative within one state, may reach out in their influence and become damaging or destructive within another state. They should be anticipated and remedies provided before the damage is done.

While frequently similar, each conflict presents its individual characteristics and must be met and solved upon the facts peculiar to the case and by men thoroughly familiar both with the facts and the legal principles involved. The laws of each state have no force

beyond its borders. The laws of one state cannot regulate uses of water in another. One state cannot impress its eminent domain upon the resources of another. A state has a vital interest in all the air, the water and the earth within its borders, and the interests of its citizens collectively are the interests of the state. Whatever usufructuary right the citizen may have in the streams of his state, he derives from his state, and his interest can be no greater than that of his grantor. This would be true even under the extreme theory that the title of the water user is deraigned from the United States through the medium of state laws, for the constitution, laws and decisions of the courts of the state and limitations upon the rights of the state would be impressed upon the rights of the water user.

RIGHTS OF STATES

We have forty-eight states, each possessing all the inherent powers of an independent nation save as surrendered by the Constitution, and a national government of limited powers created by all the states for their common benefit, but with sufficient interest (navigation) to be a factor. With each of these states developing its territory and using the waters of its streams in its own way and in a manner best calculated to serve its needs, without regard to the needs of neighboring states and indifferent to the fact that most of our streams are interstate in character, it is evident that the field literally bristles with potential interstate conflicts, or conflicts between the states and the United States respecting the utilization of the waters of our rivers.

Solution of these problems demands statesmanship of the highest order and exercise of common sense. Mere academic rules of law enacted by legislatures or worked out by judges and but partially informed of the facts are inadequate. Natural conditions vary with each river. No set rule can govern. Each river requires it own formula. Public policy always is an important factor and frequently controls the solution. To turn over such matters supinely for solution by the United States and its prejudiced bureaus, is not only beneath the dignity of the states, but the suggestion smacks too much of the whine of the defeated. Such a procedure is un-American and is directly contrary to our fundamental principles of government. Its suggestion is its own refutation. The states possess the powers to solve such problems. It is their duty to exercise those powers in harmony with the provisions of the Constitution, and to work out

each problem in a manner calculated to preserve the political integrity of each sovereignty, and at the same time to do justice between them.

Certain fundamental principles control. Their recognition points the way of solution of interstate river problems in a statesmanlike manner. To ignore those principles is to defeat the desired end.

Each State of the Union possesses every power and attribute of sovereignty possessed by an independent nation, save as surrendered to the federal government by the Constitution. Each state is equal in sovereignty with all the other states. Each new state came into being endowed with all the powers possessed by each of the original thirteen. In legal effect, the new state was in being on the day of the birth of the nation and not as of the day when Congress admitted it to the Union. This equality of powers and jurisdicton over rivers facilitates the solution of interstate problems and prevents undue claims of preference.

FEDERAL JURISDICTION

The powers and jurisdiction of the United States over the waters within the territory of the new states wherever situate, are no greater than the jurisdiction over the same subject matter within each of the original states. In other words, Maine or Arizona both possess the same jurisdiction over their waters as that retained by New Jersey over the waters within her territory. Were it otherwise, the new states would be admitted upon an inequality with the original thirteen. With a state like Arizona, where water is the first essential to existence, such an inequality might destroy statehood.

Each state, in its sovereign capacity, owns and exercises jurisdiction and control over all the waters within its territory subject only (1) to the jurisdiction of the United States to regulate navigation, and (2) to adjustments of interstate relations. As aptly stated "the states have authority to establish for themselves such rules of property as they may deem expedient with respect to the streams of water within their borders, both navigable and non-navigable, and the ownership of the lands forming their beds and banks; subject, however, in the case of navigable streams, to the paramount authority of Congress to control the navigation so far as may be necessary for the regulation of commerce among the States and with foreign nations." (United States vs. Cress, 243 U. S., 316, and cases cited.)

While the powers of the United States to regulate interstate and foreign commerce are plenary, all other powers and jurisdiction over territorial waters inherent with a nation remain with each state and are reserved by it. It may take such measures as it sees fit to protect its property and jurisdiction. In the language of the Supreme Court "the constitutional power of the state to insist that its natural advantages shall remain unimparied by its citizens is not dependent upon any nice estimate of the extent of present use or speculation as to future needs. The legal conception of the necessary is apt to be confined to somewhat rudimentary wants, and there are benefits from a great river that might escape a lawyer's view. But the state is not required to submit even to an aesthetic analysis. Any analysis may be inadequate. It finds itself in possession of what all admit to be a great public good, and what it has it may keep and give no one a reason for its will." (Hudson Water Co. vs. McCarter, 209 U. S., 349.) The rights of a citizen are deraigned from his state and can be no greater than the rights of his grantor. Any limitation upon the jurisdiction of a state over its territorial waters bind the water user (Kansas vs. Colorado, 206 U. S., 46)

INTERSTATE ADJUSTMENTS

We are confronted with the fact that the settlement of interstate river problems is the settlement of controversies between sovereignties and not between mere individual appropriators or water users within either of the states. The problems involved are of an international character for each state is a nation within itself, eccept for federal purposes. The same rules and considerations of public policy are presented as would be involved in an international situation.

With the exceptions noted, each state possesses plenary powers over the waters within her borders. Each may use, pollute and control them and give no one a reason for her will. Yet the waters of her streams flow into other states where they must be used for their benefit. Those states have some interest in the river. The definition of that interest and the successful administration of the uses of the waters of interstate streams are matters for interstate consideration and adjustment. These states, of equal powers, sovereignty and dignity, all are entitled to live and prosper. The destiny of states should not be made to conform to the results of a mere contest of speed as between water users in the respective states. The equitable apportionment of the benefits between the states involves

greater questions than the mere settlement of questions of first user. A state should not be fettered and her peace, prosperity and general welfare determined by activities within another state. But there must be some method of adjustment of their interstate problems.

Rivers have not been the cause of wars, probably by reason of the gradual changes or encroachments. River conditions might arise which would be considered sufficient cause for declaration of war. But our states are not interested in this method of settlement by reason of their surrender of the right to wage interstate warfare.

Congress has no power to settle interstate controversies (Kansas vs. Colorado, 206 U. S., 46). Provisions of the Articles of Confederation in these respects were superseded by the Constitution. Congress has no power to apportion equitably the water of a stream between the interested states, to allocate to any one of them a definite portion of the common supply or to determine which one of many different uses shall have preference over the others or how the waters within a state should be administered. For Congress to attempt to expand her jurisdiction over navigable waters beyond the intent of the Constitution would be an unconscionable federal encroachment upon state jurisdiction. To attempt to extend the federal jurisdiction over all streams merely because they constitute ultimate tributaries of navigable waters would be unconstitutional and federal encroachment by subterfuge. Such a policy would lead to complete federal usurpation of state jurisdiction, within all the states, over that element most vital to the welfare and existence of the states.

The states are not without remedy. While Congress has no power to settle interstate controversies or to allocate the waters of an interstate stream between the interested states and while the states have surrendered their inherent right to settle their differences by resort to arms, they retained to themselves all inherent powers of entering into treaties or compacts with each other, subject only to consent of Congress, and they created for themselves a Supreme Court and endowed it with the powers of an international court with jurisdiction to both adjudicate all controversies between the states and to enforce its decrees. In other words, two methods for settlement of interstate controversies are available, (1) interstate treaties, compacts or agreements and (2) original suits between the states before the United States Supreme Court.

SUITS BEFORE THE UNITED STATES SUPREME COURT

Original suits before the Supreme Court are of the highest order of litigation. They are our substitute for war between the States. While such suits afford a peaceful method of settlement, the tremendous importance of the issues involved and the consequent magnitude of the labors essential to a proper presentation of interstate water suits make them a proceeding of last resort. There could be no greater calamity than a decision of the Supreme Court in an interstate river dispute where the Court has been misguided by reason of failure of the states properly and completely to enlighten the Court respecting all matters pertinent to the issues. To marshal fully all the facts and to present them clearly and tersely to the court in a manner demanded by the importance of the issues, usually is a herculean task requiring a decade and the best services of a considerable number of experienced lawyers, engineers and experts with a corps of assistants. The attorney general of each state, by virtue of his office, is the chief counsel for his state. But his tenure of office is short and all too frequently both he and his successors are not only ignorant of the facts and the principles of law involved, but their time while in office is so consumed with ordinary state affairs that they are unable to give adequate attention to the more important interstate litigation. There is nothing spectacular to excite frequent publicity in either the preparation or the presentation of the evidence in an interstate water suit. While the issues are wet the facts furnish very dry reading for even the best informed. The greatest degree of foresight and prophetic vision of future needs and conditions is required. In the time elapsing between the commencement and the final submission of the case, human ills and unavoidable events incapacitate those engaged in the case and resort frequently must be had to the services of subordinates or of new talent which must be informed before becoming sufficiently advised to hazard active service.

The difficulty of conveying to the mind's eye of the court the natural conditions calling for visual evidence frequently approaches the impossible. Without this information the court is precluded from an enlightened consideration of the case and its decision may be unjust because of the lack of adequate information. Judges are only human. Even where good fortune permits a fairly comprehensive submission of the facts, the enormity of the record and the multitude

of collateral issues and legal principles involved, call for prolonged and uninterrupted consideration by each of the nine judges called upon to decide the case. With a court already overburdened with litigation, such a task approaches the impossible. This compels the court to assign the major consideration of the case to a master in chancery with power to consider the whole case and recommend a final decree. In other words, while such cases are of first importance and constitute the highest order of litigation and call for the first and best efforts of all the members of the court, the very enormity of such cases cheats the litigant states. There are instances, such as in the recent Great Lakes case, where the court was generously granted the time and services of so eminent a lawyer, jurist and statesman as Charles E. Hughes, master in chancery, but such is not the usual good fortune of litigants. Added to all these factors is the ever present and, too frequently, controlling one of prolonged and burdensome expense upon the litigant states and those of their citizens and property owners who share in the undertaking. Prolonged and expensive litigation does not appeal to the generosity or even to the good judgment of the average member of state legislatures which must appropriate the money to foot the bills. The best interests of the state are defeated by a spirit of over-economy upon the part of its good intending legislatures. In the final analysis, it is impossible for judges, however able or conscientious, to decide fairly and accurately the issues in a great interstate river case without the benefit of enlightenment through personal observation and study of the physical facts first hand. This prevailing objection, with a multitude of others, calls for some more direct method of settlement where considerations of fact, law and public policy may be applied upon the ground by those best informed of the physical conditions and of the natural and artificial elements which should control an equitable determination of the whole question.

INTERSTATE TREATIES AS BEST SOLUTION

Interstate treaties afford such a method. The states still possess inherent treaty making powers, subject only to consent of Congress in order to avoid conflict between state and national jurisdictions. Article I, Section 10, paragraph 3 of the Constitution provides "No state shall, without consent of Congress, enter into any agreement or compact with another state." Such consent of Congress may be obtained either before or after the conclusion of the compact

and where the compact in no way involves federal jurisdiction it has been held that such consent may not be necessary (Virginia vs. Tennessee, 148, U. S., 503; Wharton vs. Wise, 153, U. S., 155). Interstate compacts may treat of any subject matter in which the signatory states are interested. Boundaries, fisheries, navigation, quarantine regulations and other phases of interstate relations have been settled by this method (see Appendix). Such compacts may be between two or more states or between a state or states and the United States (U. S. vs. Texas, 143 U. S., 621). In either instance, the high contracting parties are the signatory sovereignties and such treates bind and are conclusive upon all their citizens (Rhode Island vs. Massachusetts, 12 Pet., 657, 725-731).

Interstate river treaties are a recent application of a power which always existed. Compacts between states are not new. Such have been concluded before and after the formation of the Union respecting boundaries and other subjects (see Appendix). River compacts are but a new application of an old method.

Rivers have not caused wars, but international river disputes have always been recognized as a most important subject for international agreement. Even where an upper nation has been held to possess the right to exhaust wholly the water supply of an international river in order to satisfy the necessities of the nation of origin, that nation has equitably apportioned a part of the water supply to the lower nation by international treaty as a matter of policy and of international comity (Malloy, Treaties, vol. I, p. 1202). Such is the established American method. Even more appropriate is this method of settling disputes between states of our Federal Union or between a state or states and the United States. The states have renounced their right of welfare between themselves and have so placed themselves that they must either determine their respective rights in advance of conflict and settle any acute differences, by interstate compacts, or, failing so to do, undergo the pains and penalties of protracted, uncertain and unsatisfactory litigation. The wisdom of the treaty method should require no advocacy. Litigation should be considered only in extreme cases, where diplomacy has been exhausted or where the issue is the interpretation of the language of an agreement or the enforcement of its provisions.

Compacts are usually phrased in the manner of international treaties. The dignity and importance of the proceedings and the character of the contracting parties justify this custom. The signa-

tory states are represented by one or more commissioners who act for their states. They are assisted by expert advisers. The commissioners are appointed by the governors of the states either with or without previous legislative authority. The appointment is usually under authority of legislative acts wherein provision is made for expenses of the commission and assistants. However, cases frequently arise during legislative recess, which demand immediate action and where it is appropriate that the governors of the interested states appoint commissioners to proceed without delay, trusting to subsequent legislative approval to validate their acts and approve any treaty which may have been concluded. Effectiveness of interstate compacts is usually conditioned upon approval by the legislature of each of the signatory states and by the Congress. Where previous congressional consent has been obtained, it may not be necessary to submit the compact for final congressional approval although such is the better procedure.

Interstate compacts may be made by direct legislative acts. In such cases, one state legislature, by its act, makes an offer which is accepted by act of the legislature of the other state. The offer and acceptance taken together, constitute a compact between the states, with consent of Congress obtained either before or subsequent to legislative proceedings by the contracting states. This legislative method is usually availed of only where the interstate problem is simple. With the more complex problems, the states can ill afford to hazard their general welfare by proceeding other than by commissioners, surrounded by advisors. Such matters are of too great moment to be lightly considered and satisfactory results can be obtained only by protracted study, frequent discussions and frank understandings between skilled negotiators. Legislatures are too engrossed with ordinary state affairs to give appropriate time or thought to such matters and the members are not sufficiently advised to do justice to either State.

Interstate river compacts possess a strong and convincing appeal to the practical American mind. Business men, engineers, lawyers, public officials and others all recognize in this sound and practical method a way out of both actual and potential difficulties. Capital cannot safely invest in securities based upon titles to the uses of water, whether for power, irrigation, domestic or other purposes, without permanence of titles. The magnitude of our undertakings demands such security. We can no longer build upon unsettled titles to the

use of the waters of interstate rivers. Courts do not determine such matters in advance of acute conflict. The Supreme Court refuses to try moot cases. Such was its ruling in the cases brought to test the validity of the Federal Water Power Act. Litigation furnishes no method of determining in one proceeding all the problems respecting the future orderly administration of uses and the permanent division of the benefits from the waters of an entire stream system.

All problems respecting the use or disposition of the waters of an interstate river may be settled and usufructuary titles may be fixed in advance of conflict by interstate compacts and agreements. Preference of uses in times of scarcity; guaranty of the dominance of the more necessary uses over the less imperative; assurance to the states of origin of sufficient water from their streams to supply their future needs irrespective of the time or method of making such uses; assurances of the permanence of the water supply necessary to the operation of works along the lower reaches of a river for municipal, agricultural, power or other purposes; comprehensive development of an entire river system in a manner best calculated to obtain the maximum benefits from the common water supply; making wasteful uses of water for purposes of navigation subservient to the more imperative needs of mankind; prevention of wastes; systematic regulation of all problems respecting the disposition, purification and other necessary control of sewage and other polluted waters; creation of interstate boards of control or authorities permanently to administer uses and enforce prohibitions and regulations upon a river system; all these and a hundred and one other desired objects may be speedily, economically and successfully accomplished by interstate compacts.

The dignity of states guarantees the fulfillment of their treaties. The very fact that each treaty came into being only by the unanimous consent of all the commissioners for the signatory states and upon legislative approval by those states and by the Congress, gives assurance of stability and good faith. The protracted study, research and investigation by each of the commissioners necessary to intelligent consideration of the problems involved, the absence of that bitterness and partisan prejudice usually engendered in the heat of conflict, the gradual removal of obstacles as the negotiations proceed, the period for rest and reflection between sessions of the commission and the other human factors that go to bring unanimity of thought and expression, all these and more assure justice, the protection of the interests of all and permanence of agreement.

Interstate river agreements not only define the rights of the signatories to beneficial uses of the common water supply and provide permanent means of administration of such uses, but reduce to the minimum those acute conflicts which cause interstate litigation. The Supreme Court has jurisdiction to interpret every interstate compact and to enforce its provisions. The states not only have power to enter into treaties but have created a court with original and exclusive jurisdiction to enforce their agreements. Property rights founded upon the terms of interstate compacts are assured of protection by original proceedings before the greatest court in the world.

River treaties are not perfect. Like other agreements, their perfection depends upon the learning, skill and patient endeavor of those responsible for their formulation. The "do it now" fad prevalent in the present day businesss world has no place in council chambers of interstate river commissions. Common sense, practical and technical knowledge, infinite patience, mature reflection, kindly consideration of the rights of others and an appropriate degree of self defense, must there prevail. Academic minds are of small value. Even where well drawn, interstate compacts are not a panacea. They are only as good as the commissioners make them. A good compact is a blessing. A poor compact is worse than none, a curse to the signatories and a bad record for those who drew it. Compacts hastily drawn by bigoted, partisan and unskilled commissioners should not have been conceived. Although interstate river compacts were but recently adopted as a method of dealing with acute river situations, already there are signs of a disposition to negotiate them hasitly in a wholesale fashion. Such efforts are premature and may result in more harm than good. But few of the citizens of any state are equipped or circumstanced to represent their state upon interstate river treaty commissions. Our people think in local terms. Interstate or international relations are seldom within our range of thought or action. Our states have not developed a diplomatic service from which to draw. Safety demands that interstate compacts should evolve in step with the leaning of the negotiators. We must proceed with caution. Undue haste is worse than no action at all. We must not go before we are ready. Methods of treatment of the problems pertinent to one river system may be out of place as regards another stream system. Water titles are perpetual in their nature and extreme caution should attend a definition of their limitations. Compacts fix the destinies of millions of people

yet unborn. They deal with the future and not with the past They are the basis of titles which will be of fabulous ultimate values. The whole future of our rivers and of the cities, farms, industries and institutions which will be founded upon the use of their waters, may depend upon the rightful use and not the abuse of the interstate compact method of dealing with interstate river problems. We advocate its judicious use but earnestly protest against its promiscuous abuse.

Our Federal Union will endure or fail as the states are strong or weak. The autonomy of the states must be our first concern. Interstate litigation, strife, turmoil and uncertainties of titles and jurisdiction respecting our rivers will undermine our whole governmental structure. To nationalize our streams would tend to destroy our nation for, thereby, the states would be deprived of control of that natural element essential or imperative to their very existence. The agency which controls the element will control the states. To preserve to the states their jurisdiction over their rivers is to preserve the states. The interstate river treaty method preserves state sovereignty. It retains control of rivers with the states where it belongs. It encourages harmonious intercourse between the states and mutual regulation of their own interstate affairs. It keeps government with the states and not at Washington. It preserves the states and perpetuates the Nation.

APPENDIX

Interstate compacts respecting rivers of the western states are the evolution of experience with interstate river litigation over a quarter of a century. There water is scarce and land plentiful. Practically all of the rivers flow through two or more states or are tributaries of such rivers. The waters from the mountains evaporate as the rivers pass over the plains. Colorado development at the headwaters of the important rivers was followed by a cycle of dry years. This brought about conditions which provoked a series of interstate river suits against Colorado. This litigation was prolonged, very expensive and extremely unsatisfactory to all parties. All recognized that such suits were destructive of state autonomy and were opening the way to federal encroachment upon state sovereignty. This realization became acute when the Attorney General announced the federal policy to be that of claiming that the United States owns and may control and dispose of the waters of western rivers regardless of the will

of the states and that such waters never have been within the jurisdiction of the states.

These conditions demanded a more direct, immediate and comprehensive method of solving interstate river problems.

During the litigation between Wyoming and Colorado, respecting the Laramie River, there were informal conversations between some of the attorneys respecting interstate treaties and such a method is mentioned in the briefs for Colorado. The South Platte (Nebraska-Colorado) suit was commenced in 1916. At the outset, counsel for Colorado canals adopted a policy to facilitate conclusion of an interstate compact in lieu of pursuing the ligitation. Although this was the first western river respecting which an interstate compact was undertaken, the compact was not concluded until 1923 and approved by Congress until 1926. The Colorado River and the La Plata River Compacts resulted from the pioneer work of the South Platte and while initiated subsequently, were concluded at an earlier date. The joint engineering investigation between Wyoming and the United States respecting the North Platte River was made in 1918 and 1919 and opened the way to negotiations for a three state compact.

The publicity pertinent to Colorado River problems directed attention to the Colorado River Compact and caused recognition of the treaty method as an expeditious and comprehensive method of dealing with interstate river problems. This encouraged initiation of subsequent treaty negotiations.

Most of the large irrigation projects in the arid west are interstate in character. They are located upon interstate rivers and, frequently, the works and lands are located in two or more states. The North Platte and Rio Grande Projects and the proposed Boulder Canyon and the Columbia Basin developments are examples. Present and future development requires the fixing of rights by compact in advance of authorization or construction to avoid interminable litigation.

The South Platte River Compact (Colorado-Nebraska) concluded in 1923, and the La Plata River Compact (Colorado-New Mexico) concluded in 1922, have been approved by Congress and the interested states and are being successfully administered. Litigation on both rivers was either dismissed or avoided by the conclusion of the compacts which permanently determined the rights of the states and their water users. The Ohio Interstate Stream Conservation Agreement,

among Illinois, Indiana, Kentucky, New York, Maryland, Ohio, Pennsylvania, Tennessee and West Virginia, respecting phenol waters, is reported to be operating successfully.

EARLY COMPACTS CONSTRUED BY SUPREME COURT

Virginia vs. Pennsylvania, 1780, (11 Pet., 20).
Virginia and Pennsylvania, 1784, (3 Dall., 425).
Virginia and Tennessee, 1802 and 1856, (148 U. S., 503, 511, 516).
Virginia and Maryland, 1785, (153 U. S., 155, 162).

AGREEMENTS AND COMPACTS BETWEEN STATES TO WHICH CONGRESS HAS GIVEN ITS CONSENT

Boundary Conventions

Kentucky and Tennessee: May 12, 1820. (Stat. L., vol. 3, p. 609.)
New York and New Jersey: June 28, 1834. (Stat. L., vol. 4, pp. 708ff.)
Virginia and Maryland: March 3, 1879. (Stat. L., vol. 20, pp. 481ff.)
New York and Vermont: April 7, 1880. (Stat. L., vol. 21, p. 72.)
New York and Connecticut: February 26, 1881. (Stat. L., vol. 21, pp. 351ff.)
Connecticut and Rhode Island: October 12, 1888. (Stat. L., vol. 25, p. 553.)
New York and Pennsylvania: August 19, 1890. (Stat. L., vol. 26, pp. 329ff.)

Protection of Fish in Boundary Waters

Oregon and Washington: April 8, 1918. (Stat. L., vol. 40, p. 515.)

Jurisdiction over Boundary Waters for Specific Purposes

North Dakota, South Dakota, Minnesota, Wisconsin, Iowa, and Nebraska; March 4, 1921. (Stat. L., vol. 41, pp. 1447ff.)

Construction and Operation of Tunnels

New York and New Jersey: July 11, 1919. (Stat. L., vol. 41, p. 158.)

Development of the Port of New York

New York and New Jersey: August 23, 1921. (Stat. L., vol. 42, pp. 174ff.)
New York and New Jersey: July 1, 1922. (Stat. L., vol. 42, pp. 822ff.)

Erection, Maintenance, and Operation of Waterworks

Kansas and Missouri: September 22, 1922. (Stat. L., vol. 42, p. 1058ff.)

Apportionment of the Waters of Western Interstate Streams

Colorado and New Mexico: The La Plata River Compact, January 29, 1925. (Stat. L., vol. 43, p. 796ff.)
Colorado and Nebraska: the South Platte River Compact, May 6, 1926. (Stat. L., vol. 44, part 2, p. 195.)

INTERSTATE RIVER COMPACTS AWAITING APPROVAL

The Canadian River Compact, New Mexico, Oklahoma and Texas.
The Colorado River Compact, Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming.
The Delaware River Compact, New York, New Jersey and Pennsylvania.

INTERSTATE RIVER COMPACTS UNDER NEGOTIATION

Arkansas River: Colorado and Kansas.
*Columbia River: Idaho, Montana, Oregon and Washington.
North Platte River: Colorado, Nebraska and Wyoming.
Rio Grande River: Colorado, New Mexico and Texas.

INTERSTATE RIVER COMPACTS AUTHORIZED BY CONGRESSIONAL OR LEGISLATIVE ACTS

Belle Fourche, Cheyenne: South Dakota and Wyoming.
Snake: Idaho, Oregon, Washington and Wyoming.

POTENTIAL PROBLEMS

Artesian Basin Regulation: North Dakota and South Dakota.
Big Sioux: South Dakota and Iowa.
Caney: Kansas, Arkansas and Oklahoma.
Grand: Kansas, Missouri and Oklahoma.
James: North Dakota and South Dakota.

STATES INVOLVED

Of the twenty-two states west of the Mississippi River, twenty are or soon will be involved in interstate river compact negotiations. Of the twenty-six states east of the Mississippi, the rivers of ten are covered by compacts with potential negotiations respecting others.

* Congressional act of March 4, 1925: March 3, 1927, extended to December 31, 1930.

PROBLEMS IN VALUATION AND RATE MAKING[1]

By E. E. Bankson[2]

Solution of the various problems in valuation and rate making follow stereotyped methods much less than one might suppose. It is true that an outline of the principal plans and processes will closely correspond in the majority of cases, but it is also true that the physical and financial facts may differ greatly in each case, and that nearly every situation may have one or more problems seldom found elsewhere in similar form.

Among the more common purposes of a valuation are those for purchase, condemnation, financing and rate making, but the procedure for even these may differ widely because of different laws and practices in different states.

By reason of these references applying partly to cases now in process of presentation or adjudication, we can bring them in review only generally, and among those of special interest, to the speaker and others in Pennsylvania, is the Williamsport Case, originally coming under what is known as the Act of 1874 (Pennsylvania) whereby a municipality may acquire the local private water plant by paying "the net cost of erecting and maintaining the same" together with 10 per cent interest thereon, less all dividends declared and paid.

Not being content with the special features of the Act of 1874 the Williamsport case is now further removed into the "special" class by reason of a stipulation, by the parties, resulting in an order and judgment of the local court whereby the price is fixed at which the property may be taken over and then a formula is stated for adjusting the price to any date subsequent to the order and judgment; the wording of this latter formula being very similar to that in the Act of 1874.

Before the creation of a Public Service Commission in Pennsylvania the formula, in the Act of 1874, was construed to mean "Construction and Ordinary Maintenance Costs" while the Public Service

[1] Presented before the Central States Section meeting, August 24, 1928.

[2] Consulting Engineer, J. N. Chester Engineers, Pittsburgh, Pa.

Commission has now defined the expression, in not less than two cases, as meaning simply "the Net Costs of Fixed Capital" under a guarantee of 10 per cent net revehue during the period of private ownership. The answer in the Williamsport case is awaited, but there is nothing monotonous about the case while it lasts.

Even the making of an inventory, which consists primarily of drudgery and hard work, encounters broad differences in types of construction and practices followed in each state or city, to the end that justice will not be developed through the use of stereotyped detail methods. For example, the West Virginia Commission requires that the utility run the service line to the property line and that the meter be housed at the curb (by the utility)—both features being unusual practice, but producing excellent results, while the city of Pittsburgh, and others, charges the consumer for all service line costs (labor and material), except for the material cost of the corporation cock only.

Again we meet all of the variations in design as representing the ideas of different consulting engineers and designers, but of more importance in many cases is the unusual condition in excavating and trenching, for laying mains, etc. It is the experience of the writer that every district and plant has its own peculiarities and mixtures of various classes and strata, in soil conditions, to the end that local costs should be studied in each and every case; if justice is to be done. It is true that an estimate, by one of experience, may closely approach the truth; but such an estimate does not constitute strong legal proof—and the day has now come, in valuation cases practice, when good legal proof of figures submitted is of equal importance to the figures themselves.

We have found a spread in actual local costs of trenching and backfill all the way from 84 cents per cubic yard at Palm Beach, Fla., to $3.30 per cubic yard at Shenandoah, Pa., and at Marion, Ohio, the actual cost of rock trenching varies around $10.00 per cubic yard; with trap rock at Paterson, N. J., even higher. Every case should be studied in itself.

But the greatest problem of all is the question of "fair value," which is claimed by some to be at book cost, by others at reproduction cost—as of the date certain, by still others at some point between the two and as further modified by donations, obsolescence, etc. Those of us who are called upon to do the detailed work are constantly striving for the answer to this question; but as yet the

answer is not clear. We might mention that the Indianapolis case points to one extreme and the O'Fallon Railway case, from the Interstate Commerce Commission, points to the other extreme, but this latter is yet subject to final adjudication by the United States Supreme Court. In the State of Ohio, the Public Utilities Law requires that appraisals be made on unit prices "as of a date certain."

The State Court decisions cannot be converted into clear and consistent or parallel formulae for our guidance, and the Federal courts are seldom involved except in cases of confiscation. In the recent water case of Jefferson City, Mo., it appears that the Commission found "fair value" at the point midway between book cost and reproduction cost.

As an example of special problems we might refer to the South Pittsburgh case, together with the Ohio Valley case, where we do have decisions as guidance for the appraiser, in Pennsylvania, that parallel mains, in the same street, must be priced at full reproduction cost and that structures must be reproduced as they actually exist, regardless of how much the design may differ from present practice and conditions.

We are just now engaged in the condemnation case of the Passaic Consolidated Water Company at Paterson, N. J., where the pumping station buildings are constructed of beautiful and massive brownstone which is now quarried only in exceptional isolated cases. By the Pennsylvania decision, we should price the material in keeping with the existing brownstone, and then give due consideration to the exceptional feature, when casting "fair value."

We are also now involved in the injunction proceedings by the water company serving a city in south Florida, where we assisted in fixing plant value and water rates, by arbitration in 1925, at a time when land values were very high and where a plant had been built almost entirely during the period of high prices; to the end that reproduction cost as of today would be lower than book cost and the value of the large land acreage below that of 1925.

The perpetual task of the water works appraiser is to keep abreast of the fluctuations in the price of cast iron pipe, in cases where required to appraise "as of a date certain." In figure 1 the fluctuation in prices for recent years is shown, and it is of interest to note that the Pittsburgh price has varied from $14.70 in the 90's to $83.50 in the early 70's and again about 1920.

In the field of rate making, however, we find our greatest variety of problems. Almost simultaneously, a few years ago, we were called upon to defend an industrial rate of 12 cents per thousand gallons in the city of Pittsburgh (the rate for the lowest block in the schedule) and a similar industrial rate of 4 cents per thousand gallons at Ellwood City, Pa., being successful in both cases, with justice, due to the exceptional conditions.

A recent problem for the city of Pittsburgh was that of proving the net revenues sufficient, or insufficient, to pay the interest and sinking fund on the bonded indebtedness, in order, if possible, to divorce the water bonds from the general municipal indebtedness as coming under the bond limitations. In such a case many problems of exceeding interest arise by reason of substituting the sinking

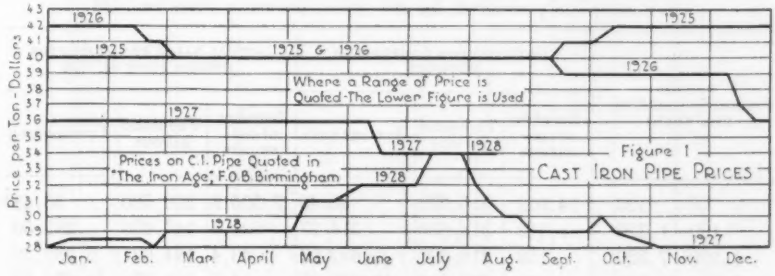

FIG. 1

fund requirements in the place of annual depreciation as intended by the Act of Assembly under which the case was conducted.

By reason of this substitution there arose the question (which was treated only in the academic) of the dividing line between maintenance and replacement costs as affecting capital expenditures and net revenues. Under the idea that where annual allowance to depreciation is high, it may cover replacement of parts and short-lived elements to a greater extent than where the annual charges to depreciation reserve are entered at a low figure.

There exists in the Florida case a problem which is more or less unusual by reason of service being rendered jointly from a common source of supply for two municipalities, which are completely separated from each other by a body of water, the problem being as to what portion of the water supply system and plant is chargeable to each municipality in fixing the proportion of the annual burden

to each municipality. One point of view indicates a division on the basis of the annual delivery to each municipality, another point of view indicating a division on the basis of maximum delivery to each municipality at any one period, while yet another viewpoint is to allocate the costs to each community in proportion to the total units of capacity in consumers meters for each group.

The problem exacting the most care on the part of the analyst, perhaps, is that of the computed prospective water sales by meter measure before the consumers have been transferred from rated to metered service. A tabular comparison is shown in table 1, for an actual case, as between computed and actual sales to average con-

TABLE 1

Water sales for 12 months ending June 30, 1928 compared with computed sales, when completely metered, by the report on water rates in 1923

RANGE (MILLION GALLONS PER YEAR)	COMPUTED FOR COMPLETELY METERED			ACTUAL SALES FOR 12 MONTHS ENDING JUNE 30, 1928		
	Number of consumers	Thousand gallons	Average each	Number of consumers	Thousand gallons	Average each
0– 120	14,012	510,070	36.40	7,596.8	269,590	35.48*
120– 1,320	1,012	318,050	314.27	521.9	147,436	282.50
1,320– 7,320	159	418,500	2,632.07	43.4	144,621	3,332.28
7,320–19,320	29	303,000	10,448.27	14.8	211,278	14,275.54
19,320–37,320	7	245,000	35,000.00	5.4	156,546	28,990.00
37,320–61,320				1.0	60,935	56,401.30
All over 61,320	4	450,000	112,500.00	4.9	613,784	125,262.00

* Including 15,847 bills rendered at zero meter reading.

sumers, at a time when metering had progressed to about the 55 per cent point. The average annual consumption for first block consumers was computed at just over 36,000 gallons per year, while the actual annual shows just under 36,000 gallons; but it is further stated that more diligence by the meter readers and the meterizing of commercial consumers (still served on rated schedule) will advance the actual to a point in excess of the computed. A diagram of consumption curves, shown in figure 2, providing the basis of foregoing computed sales, is also submitted as of possible interest to the water works man. Table 2 shows the method of computing the revenue to be derived from a metered service schedule now under consideration.

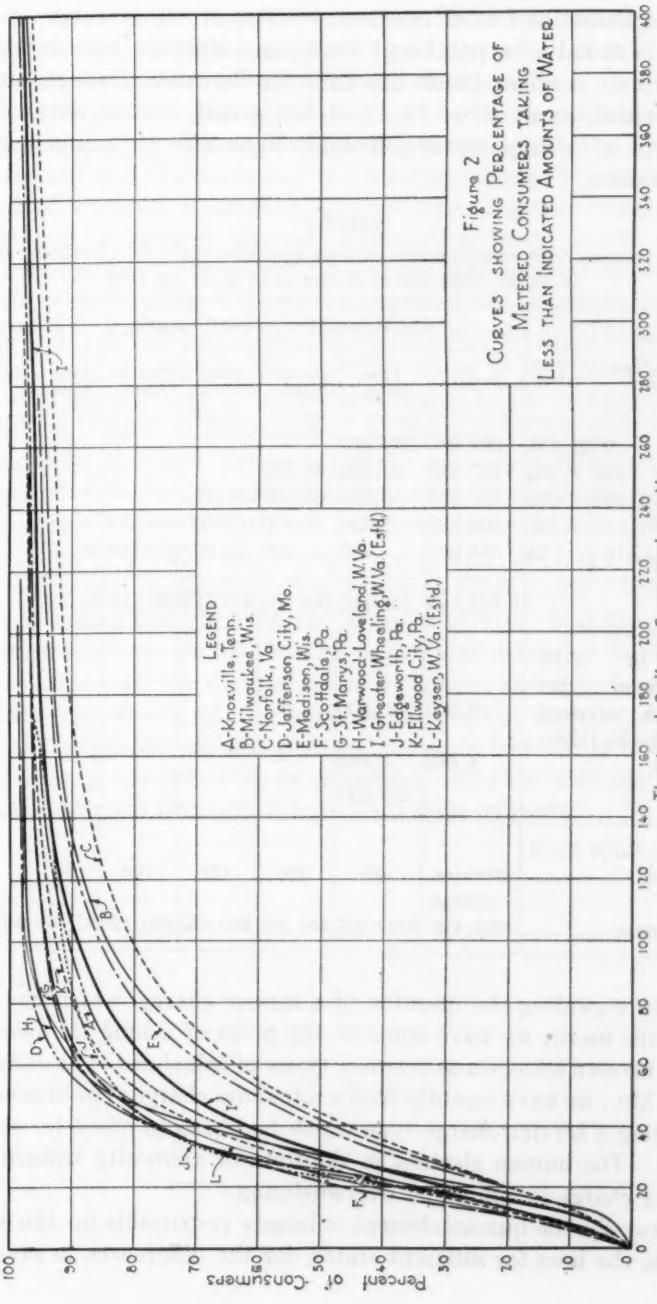
Figure 2
Curves showing Percentage of Metered Consumers taking Less than Indicated Amounts of Water.
Legend
A-Knoxville, Tenn.
B-Milwaukee, Wis.
C-Norfolk, Va.
D-Jefferson City, Mo.
E-Madison, Wis.
F-Scottdale, Pa.
G-St. Marys, Pa.
H-Warwood-Loveland, W.Va.
I-Greater Wheeling, W.Va. (Estd.)
J-Edgeworth, Pa.
K-Ellwood City, Pa.
L-Keyser, W.Va. (Estd.)
Percent of Consumers
Thousand Gallons Consumed per Year
0
10
20
30
40
50
60
70
80
90
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400

FIG. 2

The greatest and most common problem of all, however, is that of the personal view point and the human element, both in public and private service, which has thus far defeated the metering of many cities, as at Erie, Pa., and has greatly moulded the form and type of a majority of schedules, especially for municipal administration.

TABLE 2

Annual revenue from sample meter rates as applied to bills for 12 months ending June 30, 1928 and to meters as of June 30, 1928

RANGE (MILLION GALLONS PER MONTH)	NUMBER OF BILLS	ANNUAL SALES IN THOUSAND GALLONS						TOTAL REVENUE METERS
		Totals	First block	Second block	Third block	Fourth block	Fifth block	
0– 10	91,174	269,590	269,590					
10– 110	6,263	147,436	62,630	84,806				
110– 1,110	679	323,260	6,790	67,900	248,570			
1,110–11,110	133	508,837	1,330	13,300	133,000	361,207		
Over 11,110	24	355,067	240	2,400	24,000	240,000	88,427	
		1,604,190	340,580	168,406	405,570	601,207	88,427	
Gain by 1-M. minimum per month, adjusted to June 30, 1928—		10,000	10,000					
6,663		6,663	6,663					
			357,243					
Sample Tariff No. 3:								
Rates		Service charge	40¢	20¢	15¢	10¢	8¢	
Revenue		$95,410	$142,897	$33,681	$60,835	$60,120	$7,074	$400,017

Even regarding the question of a service charge, which has solid scientific merit, we have come to the point of asking the client to make his own selection as between types of schedules. At Jefferson City, Mo., we have recently filed a minimum charge type of schedule replacing a service charge type which had been in effect for several years. The human element in the form of animosity towards the service charge is sometimes overwhelming.

Naturally the human element is largely responsible for the variation in the laws for different states, for the differences in practices

by the commissions, for the variations in viewpoints as to "fair value," as well as for the apparent variation and trend in decisions by courts and public service commissions generally.

It might be said that the change in the law regarding accrued depreciation is a result of the human element. Both the American Society of Civil Engineers and the American Water Works Association had adopted committee reports approving the sinking fund method of computing accrued depreciation; some public service commissions have recognized the sinking fund method either alone or with other methods, but some commissions had constantly used the straight line method of computing accrued depreciation, until at the present time the law on this question seems to have developed to the point of relegating either method largely to the background and specifying "observed depreciation" as the only proper method.

Engineers of sound judgment, in the past, have intended giving due weight and consideration to all pertinent facts regarding accrued depreciation of particular items and have deviated their course for such items to produce results in keeping with the facts, thus permitting routine methods of computation to prevail only where there were no actual facts or evidence to the contrary. But the present situation narrows the field of the novice and delegates the task of depreciation more to those of sound judgment and experience.

These differences, at the hand of the human element, may be partially ironed out as time goes on, but state boundaries and other barriers may always exist to prevent a complete meeting of the national, or eveu the local, minds upon these subjects.

MOTOR DRIVEN CENTRIFUGAL PUMPS[1]

By R. L. Baldwin[2]

Great improvement and consequent increase in the use of the centrifugal pump have resulted since the first pump of this type was introduced over one hundred years ago. The use of this type of pump has seen its great development since the introduction of the electric motor. It is this combination of equipment which the writer will consider. Almost every waterworks man must at some time have something to do with this type of equipment. It is the writer's plan to consider some individual installations as illustrating different problems that arise.

PUMP CHARACTERISTICS

It is well to understand the theory of this type of pump in advance so that its advantages and limitations may be kept in mind. Their action is dependent upon centrifugal force. An "impeller" is rotated at a high speed which tends to discharge the water at its periphery at a high velocity. The surrounding casing is so designed as to convert the velocity of the water, leaving the impellers, into pressure. The speed of a point on the periphery of the impeller is a measure of the pressure that can be created.

For a given diameter impeller the quantity discharged will vary directly as the speed and the head or pressure will vary as the square of the speed. Since the work done or power necessary is the product of the quantity of water pumped and the pressure or head pumped against, the power varies as the cube of the speed. There are definite speeds for standard motors and as most electric power is furnished as 60-cycle alternating current the motor speeds are 600, 720, 900, 1200, 1800 and 3600. For a given speed the quantity or capacity of the pump varies as the diameter of the impeller, the pressure or head developed varies as the square of the impeller diameter and the power varies as the cube of the impeller diameter.

[1] Presented before the Missouri Valley Section meeting, October 2, 1928.

[2] Burns and McDonnell Engineering Company, Kansas City, Kans.

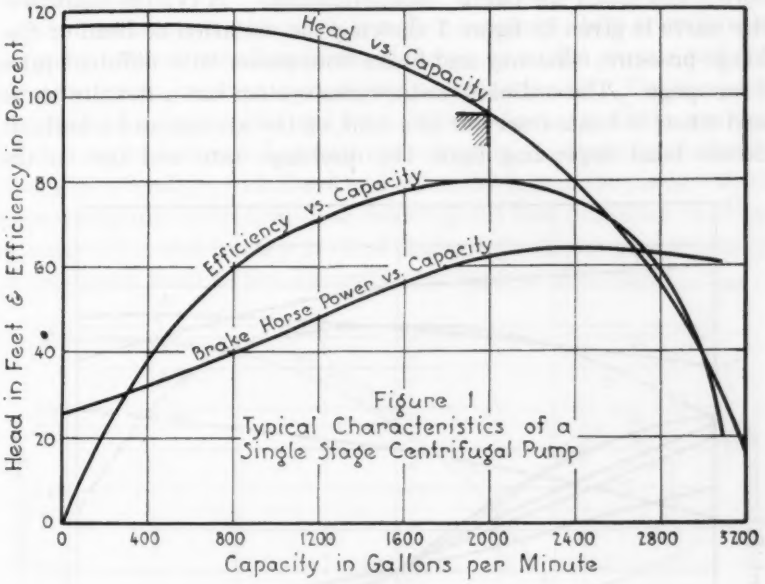
Head vs. Capacity
Efficiency vs. Capacity
Brake Horse Power vs Capacity
Head in Feet & Efficiency in Percent
120
100
80
60
40
20
0
0
400
800
1200
1600
2000
2400
2800
3200
Capacity in Gallons per Minute
Figure 1
Typical Characteristics of a
Single Stage Centrifugal Pump

FIG. 1

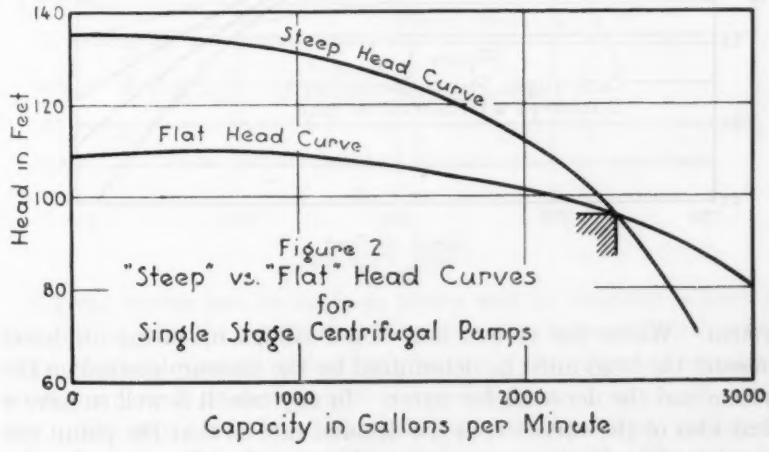
Steep Head Curve
Flat Head Curve
Head in Feet
140
120
100
80
60
0
1000
2000
3000
Capacity in Gallons per Minute
Figure 2
"Steep" vs. "Flat" Head Curves
for
Single Stage Centrifugal Pumps

FIG. 2

The manufacturers make tests of their pumps and these data are plotted and called the pump "characteristics." A typical characteristic curve is given in figure 1 showing the variation of head or discharge pressure, efficiency and brake horsepower with different rates of pumpage. The ordinary waterworks system has a definite static head where it has a reservoir or a tank on the system and a variable friction head depending upon the discharge rate and use on the

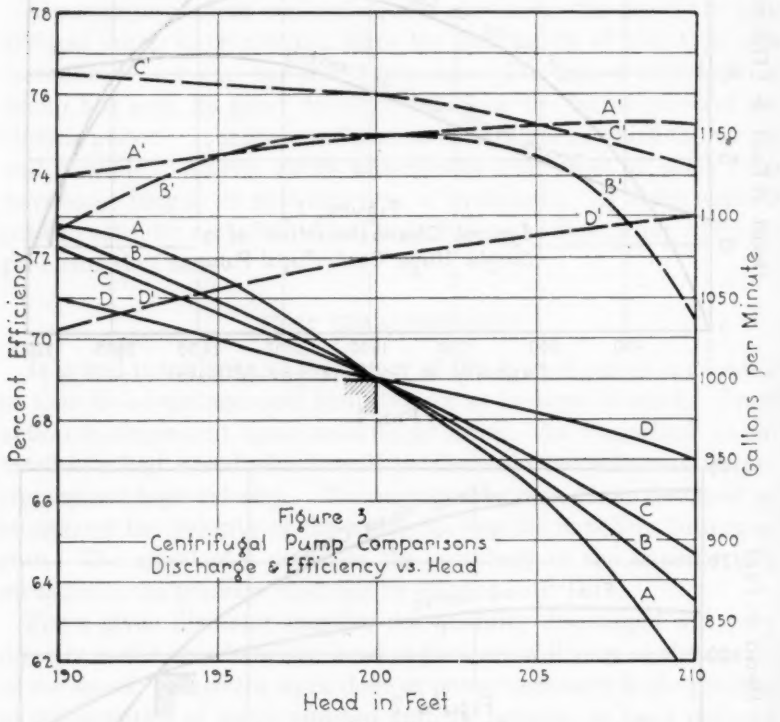

FIG. 3

system. Where the system is a closed system operating on direct pressure the head must be determined by the pressure desired on the system and the demands for water. In any case it is well to have a clear idea of the variation in the demand rate so that the pump can be selected to fit the particular conditions. Impellers can be designed so as to have a "steep" head curve. Where a variable head is encountered and it is desired to have the minimum of variation in capacity such a design is desirable. Other conditions may require a

practically constant head and a variable capacity in which case the impeller should be designed for a "flat" head curve.

When pumps are selected it is well to compare their operation at different heads as so often elevated storage is on the system and the head may vary between certain fairly definite limits. The comparison of three pumps submitted for a definite discharge at the average head is shown in figure 3, giving the variation in discharge and efficiency at a head ten feet above and below the guarantee point. Such a comparison is often helpful in selecting the best pump for the conditions. It is well to keep in mind that a high discharge is necessary at maximum head as fire demands may come at such times.

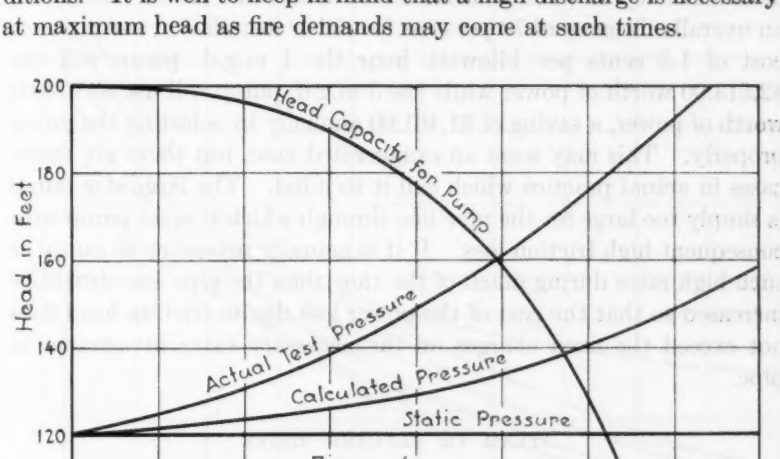

FIG. 4

FRICTION HEAD

A great saving can be made in power cost by carefully selecting the unit to suit the conditions. Suppose you have a system with ample elevated storage so that the pumps may be operated and shut down for periods as desired and power is purchased on an off peak rate. The water may be pumped during an eighteen-hour period or it may be pumped in a very short period, say six hours. The attendance required will not vary since it is necessary to have a man at the pump station anyway. If it would require a 3 m.g.d. pump to furnish the required amount of water in six hours, then a 1 m.g.d. pump

would be ample for the eighteen-hour period and would satisfy the demands just as well. Upon investigating it is found that the static head is 125 feet and the friction head is 10 feet at the 1 m.g.d. rate, and 90 feet at the 3 m.g.d. rate. Then the total head required is 135 feet for the 1 m.g.d. pump and 215 feet for the 3 m.g.d. pump, and the power required is directly proportional. In other words, it would require approximately 60 per cent more power to pump the water with the 3 m.g.d. pump than with the 1 m.g.d. pump, and the service would be just the same. This is a large difference, but it may mean more to you when translated into dollars and cents. Assuming an overall efficiency of 70 per cent for either installation and a power cost of 1.5 cents per kilowatt hour the 1 m.g.d. pump will use $2,513.00 worth of power while the 3 m.g.d. pump will use $3,974.00 worth of power, a saving of $1,461.00 annually by selecting the pump properly. This may seem an exaggerated case, but there are many cases in actual practice which call it to mind. The large size pump is simply too large for the pipe line through which it must pump with consequent high friction loss. If it is actually necessary to pump at such high rates during much of the time then the pipe size should be increased so that the cost of the power loss due to friction head does not exceed the fixed charges on the necessary extra investment in pipe.

STEAM VS. ELECTRIC DRIVE

It is often necessary to decide between a steam-driven pumping unit and a motor-driven unit. The results of a study made for a new pumping station to be equipped for 10 m.g.d. capacity at once and designed for an ultimate capacity of 25 m.g.d., may be of interest in this connection. An estimate was first prepared of the cost of a steam pumping station with two 5 m.g.d. crank and flywheel-type pumping units with necessary boiler plant, coal handling equipment and auxiliaries, buildings and pipe connections designed for the ultimate capacity. Next, a similar estimate was prepared for motor-driven pumps. Since the ordinary motor is constant speed it was necessary to use different sized pumps to satisfy the varying demands since the system was a direct pressure system. For this reason pumps of 3, 5 and 7 m.g.d. capacity were chosen to give as nearly as possible the flexibility in operation that could be obtained with steam pumps. It was necessary also to provide space for bring-

ing the ultimate capacity to 25 m.g.d. and also for a booster to increase pressures in case of fire.

The comparative first cost was, as follows:

Steam pumping station	$235,000.00
Motor-driven pumping station	80,000.00

The operating costs of these stations will require labor, maintenance and supplies which will not vary much with use, and for this

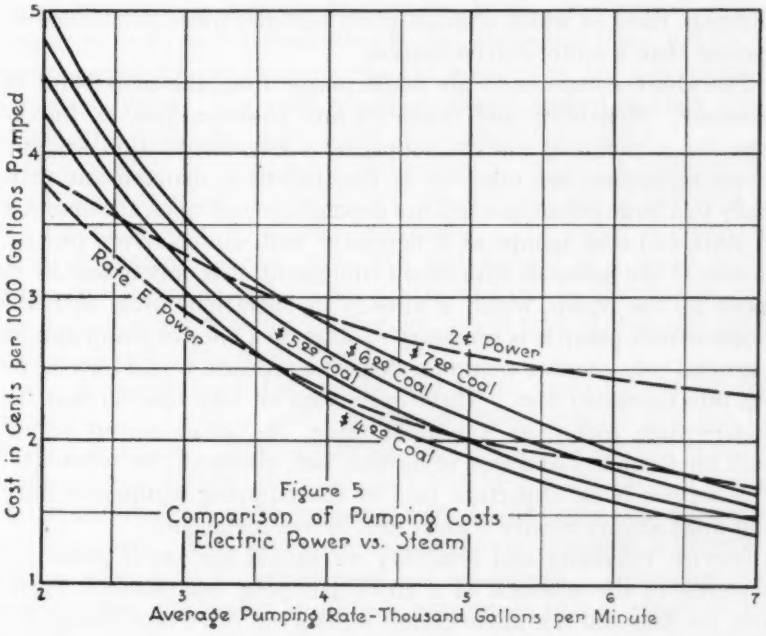

FIG. 5

purpose were assumed as fixed. Interest charges were assumed as 5 per cent and depreciation for the entire steam station was taken as 3 per cent and for the motor-driven station at 4 per cent.

The total annual fixed costs for the steam plant were	$35,300.00
The total annual fixed costs for the motor-driven plant were	17,700.00

Curves were prepared showing the variation in the cost of pumping per thousand gallons with steam and electric power at different pumping rates.

For a 2 cent power rate, the curves show that the total pumping costs will be less for electric power than for steam power, with a pumpage of 2500 to 3800 g.p.m. and less, or between four and five and one-half million daily rate, depending on the price of coal. With the Power Company's rate "E" in effect, the pumping cost will be less for electric power than for steam power with pumpage rates less than 3750 to 6500 g.p.m., or between five and nine million daily rates, depending on the price of coal. This is shown definitely on figure 5, the point of curve intersections indicating the pumpage rates at which a steam plant becomes more economical to operate than a motor-driven station.

The above comparisons are made purely from the standpoint of economy. Reliability and flexibility are, however, just as important for a pumping station supplying a city distribution system. Steam equipment can take care of fluctuations in demand automatically to a large extent and will not depend so much upon the operator to start and stop pumps as is necessary with motor-driven pumps. In case of fire demands with steam equipment, it is only necessary to speed up the pump, which is already in operation, while with the motor-driven pump it is necessary to start up a booster pump and, as a general rule, another pump for domestic pressure would have to be put into operation first. These operations all take time so that the underwriters prefer, as a general thing, the steam-driven pump, both for flexibility and ease of control, but, above all, for reliability. Fire service is an important part of the pumping equipment duty and must always receive a great deal of consideration.

Service, reliability and flexibility we should say are of prime importance in the selection of a city's pumping equipment. Therefore, the financial side alone cannot control but often must be made a secondary matter.

It is apparent that, if this new station were necessary to care for relief of peak load conditions only, where the average pumpage would be low, the advantage from the standpoint of economy would favor the motor-driven station. It is also apparent that, if there were adequate elevated storage on the distribution system so that the motor-driven pumps could be operated at their rated capacity and head at all times, then there would be little question as to the type of equipment to use.

WELL SYSTEMS

Many water supplies must use wells and the older systems have many deep laid suction lines with low service pumps placed in deep pits. Such installations are costly to build and maintain. Pipe sizes were necessarily very large as friction losses had to be held to a minimum. When leaks developed the difficulties of location were generally so great that a vacuum pump was installed to remove the air as it collected. The draw down was limited to a suction lift of about twenty feet less the friction loss in the pipe system. The history of most such installations is that the water plane gradually lowers as the use increases so that the installation has a constantly decreasing yield. The wells would be closely spaced as their circle of influence would not be great due to the small draw down.

Late practice has used a smaller number of wells of a diameter 12 to 24 inches in which a centrifugal type of pump can be installed at the proper level to be always submerged. The motor driving the pump is generally direct connected and located in a small pump house built over the well. This type of well can be sealed from surface pollution much better than could the old type of well with individual manholes and drop pipes.

The discharge lines then can be laid at the usual depths for distribution pipe systems and the pipe is under pressure and can be easily maintained. The motors can be arranged for remote or automatic control and the operating labor kept at a minimum. A recent design consists of 7 wells, capacity 1000 gallons each, spaced about 600 feet apart. Well houses are without tower, but each is provided with a 2-ton hoist to handle pipe and equipment. Drop pipe and shafting were purchased in 10-foot sections so that it could be installed or taken out in the headroom available. The discharge lines were brought together into a main which passed through a central control house where all water was metered and provision made for the application of chlorine. This house contained also the electrical control lines for all wells. Power was purchased at 4000 volts and this voltage was used for the individual motor, thus avoiding a transformer substation and obtaining a very low power rate. The switchboard consisted of a receiving panel with one oil switch from which the power was taken by underground to each well house. Disconnects were provided at each house ahead of the automatic starting panel with local push button control as well as the

push button control in the central control house. Each house was provided with a small transformer for lights and power to operate the solenoids. A four-wire control cable connects each well house with the central control house and each push button station is provided with red and green pilot lights so that the operator can know at a glance what wells are in operation.

The cost of pumping from wells by this means compares very favorably with that by any other system and, if given a good load factor, will pump water at a cheaper power cost than any other system. It also has a very low maintenance cost. These pumps operate against 70-pounds pressure and with a 25 per cent load factor pump water at a cost of 4 cents per 1000 gallons, which decreases to about 1.75 cents per 1000 gallons at full load.

This type of pump serves a good purpose as a low service pump where the water is taken from a river or other source having a wide variation in water level The pump may be submerged while the motor is installed well above maximum high water and the whole unit suspended from the surface so that no foundations or working parts are located in the pit, but can all be withdrawn by hoisting the pump to the surface, when necessary.

AUTOMATIC OPERATION

In the use of motor drive it is possible to use automatic operation in many cases, making a great saving over the labor costs ordinarily required. For small districts, where boosters are required to serve them satisfactorily, a pressure type control can be used. Where possible, however, the control line should come from the tower and tank directly so that variations in pressure due to friction losses or use of water on the system will not cause the pump to start or stop. Such installations have been installed and operated on water-works and sewer systems for a number of years and require only an inspection every day or two. They give excellent service.

Where the distance from the tower and tank is great an electrical method of transmission of the start and stop impulses is desirable and very reliable devices have been perfected and are in use.

We have an automatic station serving a city where there are 3 pumps having capacities of 600, 1200 and 1800 g.p.m., respectively. These pumps each have automatic starting panels which are controlled by a special panel on which is mounted a Ruggles-Klingemann regu-

lator, a dial switch, a control circuit switch, a time switch and seven double pole control relay contactors.

When the water in the standpipe drops a definite amount the R.-K. regulator moves the dial switch to the first control point and Contactor No. 1 picks up, closing the control circuit of the first starting panel, thus starting the motor of pump No. 1. If the water level continues to drop the R.-K. regulator moves the dial switch to the second control point and Contractor No. 2. closes the control circuit of the second starting panel starting pump No. 2. Pump No. 1 stays in operation until pump No. 2 is on the line when the pump No. 1 is automatically shut down. In this way various combinations of pump are obtained to accommodate the pumping capacity to the load and hold an even pressure at the load center. Of course, there is variation in the friction head and care must be taken to get pipe sizes large enough that this will always be within reasonable limits.

The time switch on the control panel mentioned above was arranged to limit the pump operation to one of the pumps during the power company's peak load period. Such operation and control depends entirely upon having elevated storage and is very desirable, giving efficient operation as the pumps are operating very close to their rated condition under this scheme.

Automatic units, however, are in use operating on different schemes and serving very good purposes. Where a well supply can be obtained at various points on the distribution system it is possible to supply the system at different points, equalizing pressures and deferring the installation of large mains. Such pumps may be controlled by a pressure type controller and started only when the pressure drops below, and stopped when the pressure reaches above a high point. Two such installations the writer has in mind are on systems having steam-operated main pumping stations. At certain periods of the year the demands are such that adequate pressures can be maintained throughout the day but at other periods there are times during the peak of each day's demand when these pumps automatically take the load in their district, thereby saving the cost of a large feeder line which would be necessary for only short periods of time.

OBTAINING LOW RATES

The lowest rate possible should be obtained for the power required for pumping. Often conditions are such that the pumping equip-

ment may be designed to take advantage of low rate schedules. Almost every power company has an off-peak rate and a discount for high power factor.

Where motors are 50 H.P. and larger in size, serious consideration should be given the use of a synchronous motor which will give high power factor or may be designed to give a leading power factor, if desired. Such motors cost little more in small sizes and may even be cheaper in the larger sizes than the ordinary induction or slip ring motor. The starters may be automatic and an untrained operator can then be used and produce no line disturbances. A saving of from 5 to 10 per cent in the power bill may generally be made in this way.

Where it is desired to obtain an off-peak rate, some elevated storage is necessary. Many systems already have some elevated storage, but often it is not enough to accomplish the desired result, and so it becomes necessary to increase the storage facilities. The cost may be prohibitive, if considered only for its saving in power cost. Generally another advantage however, in having such storage is that it equalizes the demands on the system in such a way that pipe sizes may be smaller, or it may save laying a new feeder line, thereby more than paying for itself and at the same time providing better or the same service with lower station pressures.

These advantages of elevated storage are injected here, because the motor-driven pump is peculiarly adapted to such a system. It is at a disadvantage on a closed system, and it is often necessary when installing motor-driven stations to install elevated storage at the same time.

The power company wants your load and you want a low power rate. They may not know much about your business and you do not know much about theirs, so you are not in the best position to deal with each other until you interchange information. The power company's load, as a usual thing, reaches its maximum in the winter, while the water company's load peak is in the summer or fall. The power company is very anxious to fill up the valleys in their load curve and particularly to eliminate the seasonal peaks insofar as possible so that this should be your starting point. From this you can work out your storage problem, to keep off of daily peaks, and other minor details to get a minimum rate that will be mutually satisfactory.

DIFFICULTIES AND DESIRABLE IMPROVEMENTS

A centrifugal pump is not like a positive displacement pump and can handle very little air without losing its suction. It must be primed before starting. For this reason foot valves and priming devices are necessary. Foot valves are a source of trouble and must always be installed in places difficult of access. There is generally a high friction loss through such valves, which is undesirable.

In most cases the remedy is to use a vacuum pump for priming, thereby eliminating entirely all foot valves. A system can be arranged so that a number of pumps can be automatically primed at all times. Such a system is often cheaper than large foot valves. If not, the saving in loss of head and assurance of operation at all times is worth the difference in cost.

Where centrifugal pumps are used to pump clear filtered water their efficiency remains high for long periods. When water contains grit, or carries silt and sand, as is so often the case where the supply is secured from a stream, there is a reduced efficiency as the impeller is worn down. Often the pump casing wears and for such use impeller and wearing rings should be replaced often. A check can be made easily of a pump's operating characteristics if the proper facilities are provided. Every pumping installation should have a meter for both high and low service pumps and the switchboard should have meters so that it is always possible to make a check on any pump's operation. By so doing the operator can always know what he is doing.

A pumping installation may be designed for a certain ultimate capacity and for certain average conditions. Generally, several pumps are installed, the pipe sizes are fixed and if the pumps are motor-driven the speeds are ordinarily fixed. When an additional pump is started the friction head increases due to the increased discharge rate, and the pump's capacity is decreased below what it would be when operating alone, due to the increased friction head. If a third pump is started it might add little in capacity as the increased head would cut down the discharge of every pump.

This is a very difficult situation and one that requires a great deal of study by the manufacturers of electrical equipment. A small variation in speed would take care of the situation. Where units are large enough to justify the use of steam turbines for drives, a variation of 10 per cent is easily obtainable and gives excellent service. It takes care of just this situation nicely.

An alternating current motor with this small speed variation is not yet commercially available. Speeds can be varied by cutting out field poles, but this makes too wide a variation. A resistance type controller can be used, but this is very inefficient as it is required to operate at the lower speed most of the time and at the high speed only at times of peak demand. It is more economical, however, to use resistance type controllers than it is to throttle the pumps.

The brush shifting motor gives good promise, but to date it is high priced, requires expert operators and has not been in service long enough to make it desirable as a motor for pumps on municipal supplies. If this motor or some other can be devised to give a 10 or 15 per cent speed increase when desired, even at a poor efficiency, it will find a very wide use. It would eliminate one of the worst objections to centrifugal pumps and boosters to take care of fire demands would not be necessary.

SIX YEARS' OPERATION OF FILTER PLANT AT PETERBOROUGH, ONTARIO, CANADA[1]

By R. L. Dobbin[2]

The Peterborough Plant has a capacity of 6,000,000 imperial gallons per day, and was built in 1921, first delivering filtered water in February, 1922. It is of the rapid sand type of standard design and presents few variations from many others throughout the country.

The raw water is taken from the Otonabee river about 2½ miles above the city, and pumped by electrically driven low lift pumps over an aerator into the sedimentation basin. It then flows to the filters and through them to a clear water basin extending beneath. From there it flows by gravity to a 2,000,000 imperial gallon filtered water reservoir, and thence to the suction of the high lift pumps. Just before entering the latter the water is chlorinated.

There are meters on the discharge from the low lift, the wash water, and the high lift pumps.

There is a laboratory in connection with the plant which is fitted up for making the usual chemical and bacteriological tests.

There are six filters, each of one million imperial gallons capacity, 24 feet by 17 feet, 6 inches in size. Each filter has 24 inches of sand and 18 inches of gravel, and the under drain system consists of perforated pipes.

High velocity wash, 24 inches vertical rise per minute is used, the wash water being taken from the clear water basin by wash water pumps and pumped directly into the under drain system. No wash water tank is used.

The rate of filtration is 125 million U. S. gallons per acre.

OPERATION OF FILTERS

As there is no reservoir or stand pipe connected with the waterworks distribution system, what is known as the direct pumping system is used. That is, the high lift pumps are operated as required

[1] Presented before the San Francisco Convention, June 14, 1928.

[2] Manager, Utilities Commission, Peterborough, Ontario, Can.

to keep a constant pressure in the mains, taking water as needed, from the 2,000,000 gallon filtered water reservoir on the suction side.

The rate of pumping to the city varies on ordinary days from 4,000,000 gallons per day, during the daylight hours, to 1,000,000 gallons per day at night.

The original intention on starting to run the new plant was to operate such number of filters as would keep the 2,000,000 gallon filtered water reservoir full at all times. This necessitated running only one filter during the night period. Three operators were used, one on each shift.

FIG. 1. FILTRATION PLANT EXTERIOR

After about two years operation it was found that this was not an economical method, and the following plan has now been adopted.

The plant is started at 7:00 a.m. and operated at full capacity until the reservoir is full. Then it is wholly shut down, and started again when the water level in the reservoir drops to a certain point. This schedule is followed until 10:00 p.m., and the plant shut down for the day, providing the reservoir is full.

Should the water level in the reservoir drop considerably during the night, for any reason, the operator at the high lift pumping station is able to call out a filter plant operator, who lives at the plant, and have him start the filters at once. As a general rule the plant has been shut down at 10:00 p.m. and has only run over this hour about three or four times a year.

By adopting this method the services of one operator were saved, and there were also savings in power and other items. However, it did not work out so well with regard to the quality of the filtered water.

It has been the general practice to wash each bed when the loss of head was 8 feet. This would, under ordinary conditions, result in an average filter run of 9 hours, and as long as the washing was done every 9 hours there was no trouble. But when the runs increased

FIG. 2. FILTRATION PLANT INTERIOR

to 30 hours, as they did in the fall and winter months, it was found that the same bacterial efficiency was not being obtained.

On investigation it was found that for about 18 hours run there was no considerable loss in efficiency, although the period would include a complete shut down from 10:00 p.m. to 7:00 a.m. During the time of the shut down it was found that the bacteria evidently grew in the beds. Each bed is now washed every other day, whether it has reached the maximum 8 feet loss of head or not. This practice has given good results. Of course, if the bed reaches the maximum loss of head in the meantime it is washed.

A recent test on one of the filters bears this out as shown by the following results.

FILTER RUN TOTAL HOURS	BACTERIA PER CUBIC CENTIMETER 20° GELATINE	
	Raw	Filtered
6	2,320	860
15	2,400	1,100
25	1,800	960
35	1,000	1,290
45	840	920
54	700	2,520

Between each test there was a complete shut down of 9 hours.

MICROÖRGANISMS

Twice each year, in the spring and fall, epidemics of animalculae have been experienced, which have resulted in very short runs and increased amounts of wash water.

The first experience of this trouble was shortly after the plant was put in operation. It lasted for about 10 days from May 2, 1922. The numbers of cyclops and other forms were so great that the average run dropped from 9 to 2 hours in one day. Being unused to the operation of filter plants, we did not know what to do to correct a condition that threatened to put the plant out of operation.

A sample of the raw water sent to a specialist showed the presence of these small animalculae, and he advised increasing the dose of alum. On doing so the filter runs increased, and the plant was kept up to capacity. Evidently the animalculae were held by the aluminum hydrate and precipitated in the sedimentation basins.

It has been learned when to expect the appearance of these little visitors by watching the water temperatures. Evidently a temperature of between 50° to 55°F. is favorable to their rapid increase. At temperatures lower or higher than these, they do not seem to flourish so well.

CHEMICAL FEED

Aluminum sulphate has been used as a coagulant and, on account of the moderately soft character of the water, no other chemical is used before filtration.

The feeding device is of the solution type. Two solution tanks are provided with dissolving trays and water motor driven stirring propellors. The solution passes through the orifice boxes and thence to the raw water. It was originally intended that the solution should be delivered by gravity to the discharge side of the low lift pumps. The head available for this was 3 feet. This method had to be abandoned because it was found that air accumulated in the pipes leading to the discharge main, and periodically it would erupt through the orifice boxes, and scatter the solution all over the floor.

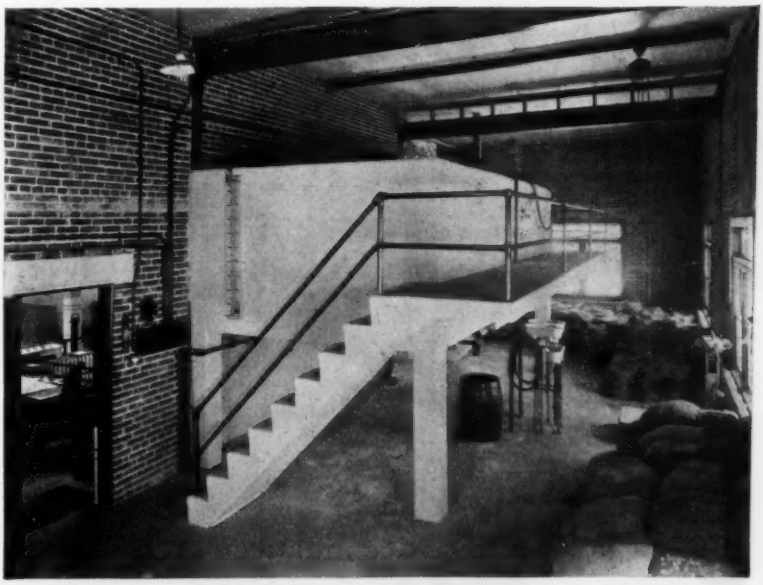

FIG. 3. ALUM ROOM

It was then decided to run the solution into the suction well, and the piping was arranged so that a branch led down into the water alongside the suction pipe for each of the low lift pumps, which are in duplicate. This method has been followed ever since, and has been very satisfactory from the operating standpoint. We were afraid that there might be some corrosive action on the pumps, but yearly inspection has disclosed none.

The quality of the floc does not seem to be affected by the action of the pumps. The only difficulty experienced with this arrangement

has been in cases where the operator had forgotten to shut the alum feed off when the pumps were shut down. This resulted in filling the suction well with an accumulation of the brown aluminum hydrate.

To get rid of this, the intake valves are partially shut down while a pump is running, thus increasing the velocity in the well. With the aid of a fire hose the deposit is flushed to the suction pipes, and pumped over into the sedimentation basin.

A $1\frac{1}{4}$ inch lead pipe was originally used to convey the solution from the orifice tanks. This pipe was found to be very hard to keep from

FIG. 4. AERATOR

flattening out under its own weight, and also the velocity in it was so slow that much sediment was deposited, and it soon plugged. It was replaced with 1 inch copper water pipe which has given excellent service for three years. It apparently is not attacked by the solution.

The orifice tanks as originally supplied had variable orifices. When it was decided not to vary the number of filters in operation at any one time, this, of course, obviated using the variable attachment. Any necessary change in the rate of alum feed was made by increasing the strength of the solution. Consequently orifices of a

fixed size were installed, and these were calibrated so that the rate of supplying the solution is always the same.

AERATOR

The aerator consists of a series of six steps, down which the water passes in a thin layer. The total head lost is 5 feet. The purpose of this aerator was to remove any odors from the raw water, and it does so to some extent, but its greatest value appears to be as an aid to mixing. A good floc has always been experienced, and this is attributed to the good mixing the water receives in passing through the pumps, the discharge piping and aerator.

The aerator was operated for the first winter, but it was found that so much ice accumulated on the steps that the flume overflowed. Since then, the aerator has been by-passed in the winter months. No difference has been distinguished in the pH value of the water before and after aeration.

QUALITY OF THE RAW WATER

The raw water is a comparatively soft one, with no turbidity, but highly colored.

A recent chemical analysis shows the following results.

	p.p.m.
Total hardness	70
Calcium	53
Magnesium	17
Free carbon dioxide	5
Chlorides	7
Sulphates	15
Iron	0.1
Maganese	0.0

CHLORINATION

Chlorination takes place in the main pump house where the high lift pumps are situated. The chlorine is introduced into the suction of these pumps by an automatic control, solution feed, vacuum type machine.

The rate at which chlorine is applied does not vary much and is governed by the results of the bacteriological tests. Daily ortho-tolidin tests are made to determine the residual chlorine, but the dose is not governed by these tests. The Provincial Board of Health

requires that there shall be a residual of 0.1 p.p.m., but it was found that, if the water is chlorinated to this amount, there is considerable objectionable taste, so we have to keep the dose down to a minimum that will give a sterile water.

WASH WATER CONTROL

The wash water pumps are in duplicate, and are electrically driven, one having a capacity of 4750, and the other, 5500 gallons per minute. They are controlled by automatic compensators, and are stopped and

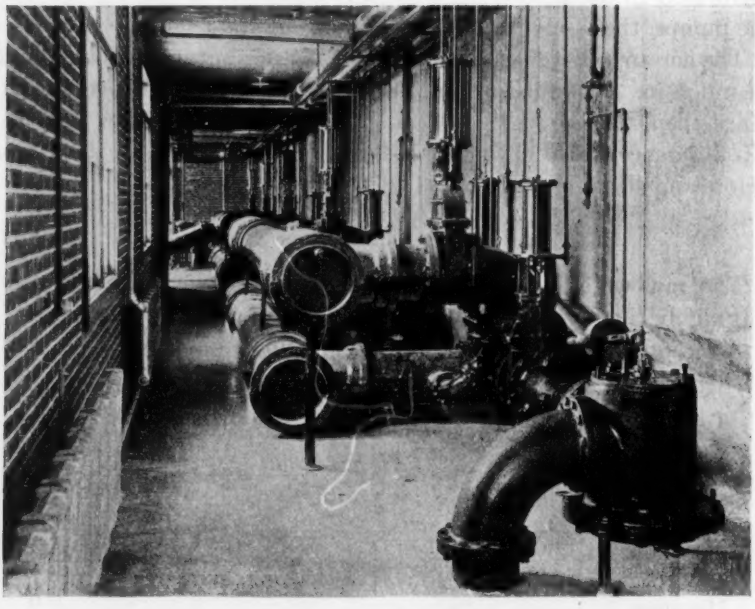

FIG. 5. PIPE GALLERY

started by push buttons located on each operating table. The lower capacity pump is used at ordinary times, the other only at the time of very short runs, when it is found to be advantageous to increase the rate of wash.

The pressure head at the smaller pump when operating at capacity is 51 feet. As the static head is 6 feet, there is consequently a loss of 45 feet in the wash water line and the underdrain system, including sand and gravel. When using the larger pump the loss is 67 feet.

Excellent results are obtained with this type of washing system, the

amount of water being controlled by the hydraulic valve on the wash water line entering the filter. The usual length of wash is 3 minutes and an average of 15,000 gallons is used for each wash.

After washing the filter-to-waste valve is opened for one minute, before opening the effluent valve.

No trouble has been experienced from mud balls, probably because of the lack of turbidity in the raw water, but there is considerable trouble from air binding, especially during the spring and fall. This has been overcome by starting the wash water pump, and just cracking the wash water valve for a very short time, until the air is all released. This is done, of course, when the water over the bed has been drawn down to the surface of the sand.

TABLE 1

Average cost of purification for six years, 1922 to 1927 inclusive

	Dollars per million imperial gallons
Alum	2.75
Operator's salaries	3.65
Power and light	2.30
Coal (heating)	0.75
Chlorine	0.35
Laboratory	0.15
Repairs	0.50
General	0.65
Total operating cost	11.10
Fixed charges (Interest, etc.)	23.70
Total cost	$34.80

CONTROL OF CHEMICAL FEED

As a general rule the amount of alum to be fed has been determined by the results of color removal. When the filtered water has a color of 10, good bacterial results are obtained.

Experiments with a view to using pH values to control the dosage have been made, but were not satisfactory.

There is, apparently some correlation between the pH value and the size of the floc, but the experience is that the size of the floc makes very little difference in the results of filtration.

The number of bacteria in the effluent can be reduced to a very small number by increasing the dose of alum, but it is found to be more economical to reduce the color of the effluent to about 10, and kill any bacteria remaining with chlorine.

TABLE 2

Summary of results of operation for six years 1922–1927, inclusive

	AVERAGE	MAXIMUM	MINIMUM
Temperature:			
Raw, degrees F	51	78	33
Color:			
Raw, p.p.m	33	62	13
Filtered, p.p.m	11	13	10
Alkalinity:			
Raw, p.p.m	86.4	94	60
Filtered, p.p.m	68.8	90	50
pH value:			
Raw	8.0	8.2	7.5
Filtered	7.5	7.9	7.2
Bacteria:			
Gelatine 20°C.:			
Raw, colonies per cc	691.9	260.0	300.0
Filtered, colonies per cc	78.6	310.0	0
Agar 37.5°C.:			
Raw, colonies per cc	54.5	160.0	0
Filtered, colonies per cc	4.8	40.0	0
Bacterium coli:			
Raw, per 100 cc	58.9	70.0	0
Filtered, per 100 cc	0.3	2.0	0
Pumpage, million imperial gallons per day	2.706	5.024	2.100
Wash water, per cent	2.11	4.0	1.35
Length of runs, hours	9.1	24.0	2.0
Alum, grains per imperial gallon	1.24	2.4	0.8
Chlorine, p.p.m	0.38	0.8	0.3

SEDIMENTATION BASIN

Water enters the basin under a baffle at one end, and discharges through sluice gates at the other end directly to the filters. The sedimentation period is 3 hours. The basin is divided by a centre wall, so that half of it can be cleaned, without shutting down the plant. Cleaning is done every month except during the winter.

It was found that most of the deposit is about seven-eighths of the distance from the entrance end of the basin, which would lead one to

think that, if the time of sedimentation had been increased, a great deal more of the sediment would be deposited, thus reducing the load on the filters.

Bacteriological tests show a reduction in the 20°C. count of 50 per cent between the raw water and the settled water on top of the filters.

No variation in the efficiency of the basins has been noticed as a result of the appearance and the size of the floc. As the temperature of the water rises we get a larger sized floc.

SIZE OF SAND

The sand as originally placed came from Joliet, near Montreal, and had an effective size of 0.38 mm. and a uniformity coefficient of 1.6. Tests made every year show no appreciable change.

FILTER PLANT PARK

The site of the plant was originally a private estate and contained many fine old trees. During construction these were protected with heavy plank guards and as a consequence remain to ornament the park. Additional trees and shrubs have since been planted, and all of these, together with the sodded banks and acres of grass, have resulted in a beautiful park.

Three cottages have been erected to house the operators, so that they are always available in emergencies.

HISTORY OF UTICA'S WATER SUPPLY[1]

By F. E. Beck[2]

To know what to do is wisdom. To know how to do is skill. To do the thing as it should be done is service. Be wise! Be skillful! But above all—give service! It has always been the principle of the Consolidated Water Company to give service.

While Utica was still a village, its 500 pioneers decided it was essential for them to have some central source of water supply. As early as 1802 the Legislature incorporated, by special act, the Utica Aqueduct Company, capitalized at $5000, which constructed a log aqueduct from springs near the present Spring Street to Genesee Street just north of Liberty Street. This primitive system was used until 1824 when that great undertaking, the Erie Canal severed the line.

This development, of course, paved the way for the future development of the Utica Water Supply. In 1832 the Utica Water Works Association laid 2½-inch iron pipes connected with the same springs near Spring Street through Cornelia Street to Lafayette Street, from Lafayette to Genesee Street and from Genesee Street under the Erie Canal to a point near Catherine Street. This organization furnished a limited supply until 1850.

Crude as the workings of these two companies must have been, there have been many evidences of the efforts to give good service, even in those primitive days.

Utica was growing slowly, but surely, and in 1848 the legislature incorporated by special act, the Utica Water Works Company. This company was founded by Thomas Hopper, who is rightfully known as the father of Utica's modern water supply.

It is interesting to know that this early pioneer had quite a task in financing this company. Many other obstacles in addition were presented, but the tremendous spirit behind the undertaking brought it through to success.

Mr. Hopper employed a man named Squire Whipple who surveyed

[1] Presented before the New York Section meeting, May 5, 1928.

[2] Engineer, J. G. White and Company, New York, N. Y.

the line for a 12-inch brick aqueduct leading from the old Graffenburg spring (well known in early days as a water cure), to the vicinity of Pleasant Street, from where a 12-inch pipe line was laid to the reservoir on Cornhill, which is almost in the heart of the present day Utica. From there a 12-inch pipe ran to the corner of Park Avenue and Daiken Street, and through Daiken Street to Genesee Street from which point distributing pipes three to five inches in diameter served all sections of the city.

The 10- and 12-inch pipes laid in 1849 are still in use. It was brought from Scotland, and will interest you because of its peculiar construction. This pipe is very thin at the top and thick at the bottom, because of the method used in those early days of casting pipe on the side.

A short time ago, our supply of soft water from the north, at Hinckley, was temporarily cut off, and the seventy-eight-year old Scotch pipe withstood the additional pressure, which was necessary to place on the distributing system by pumping from southern reservoirs to supply the city. It is also amusing to know that only one break in the pipe occurred and only one man suffered from this break. That man was Mr. Hopkins, the president of the Consolidated Water Company.

From about 1850 Utica began to grow very rapidly, and the growth of the company exceeded the expectation of the inhabitants, as is shown by the fact that the original capital of $75,000 was felt to be far more than was required. However, the Legislature rapidly increased the capital to $1,000,000 and additional financing in the shape of debentures and bonds was required from time to time.

During this period in Utica's history, every effort was made by the water company to assist industrial operators, who had located here, or had developed new industries here. You may well realize how important this assistance was, when you recall that Utica during this period was one of the world's largest textile centers.

In 1899, the present company was organized, and a list of its officers and directors is a roll of the honored names of the city of Utica.

In that year the Consolidated Water Company purchased the property of the Utica Water Works Company, and the West Canada Water Works Company. The latter company had been organized a year or so before to develop a source of soft water supply from the West Canada Creek.

Construction of the Bacot Reservoir in Deerfield was begun in

1900 and a temporary supply from Reels Creek was provided. The construction of the West Canada line began in 1905 and was put into service in September 1906. Since that date the proportion of soft water furnished in the city has continually increased. Today northern soft water is 90 per cent of the total supply.

If it had not been for the vision of these men, Utica today would not have such excellent water supply, which is sufficient for a city eight times its size. This vision has been of great assistance to Utica, both industrially and domestically. Today, Utica may grow with no fear of a diminishing supply of water.

In discussing the development of the Company, it seems almost necessary to discuss the development of the community. In the case of a public utility, one of course reflects the other.

Consequently, it would naturally seem that it would be advantageous for the utility to work hard for the growth of its community. This the Consolidated Water Company has always done. The efforts of its engineers and its executives have been devoted to the task of serving well the people of Utica, but they have also labored that the Utica of the future might also be well served, and have worked hard to build that Utica.

Through advertising and many other methods they have acquainted the people of Utica and of Central New York with the tremendous supply of water that is available. This they have done that every man may be well informed and, in discussing his city, know that the water supply is such that no man need hesitate to come to Utica and to build.

In closing, let me leave with you some interesting statistics in regard to the Utica Water supply. The total available resources of the Company are 25,656 m.g. gallons. There are a total of 253 miles of pipe laid. There are 1733 fire hydrants. Water pressure reaches an approximate maximum of 115, and an average of 75 pounds. The yearly consumption in gallons for domestic use is 1200 m.g. and for industrial use 2100 m.g.

WATER WORKS IMPROVEMENTS ON A COST PLUS BASIS[1]

By H. V. Pedersen[2]

Few managing boards of water works systems either municipally or privately owned are blessed with an over supply of funds for reconstruction purposes. In fact, it is common rather than exceptional for a water works department to be continually saving its surplus funds in order to retire bonds fifteen to twenty years after an improvement has been made rather than to save them for future improvements. Wherever a city or private corporation has permitted its water works system to run down to a point where it must go heavily in debt to raise funds for necessary improvements, it takes a long time to get out of debt. It seldom ever does for, as soon as one bond issue is retired, the system is again in bad shape and because of lack of funds additional bonds are issued to raise the money for the improvement.

In raising funds for water works improvements the private corporation cannot of course be compared directly with a municipality, but the same reluctance to spend money for reconstruction purposes exists in either case. As a rule it is comparatively easy to secure permission from either stock holder or the general public to raise funds for extension of mains, as most people readily understand that each additional block of new water mains increases the income from water rentals. In other words, there is less objection to spending money where the increased revenue will either pay for the improvement or bring a fair rate of interest on the money invested. A bond issue will usually be approved for raising funds to increase a supply of water whenever the public fully realizes that its supply is insufficient, but to tear down an old pumping station no matter how bad its condition may be and rebuild it is quite a different matter. As long as any public building hangs together it is difficult to make a majority vote in favor of a bond issue for reconstruction purposes.

[1] Presented before the Missouri Valley Section meeting, October 2, 1928.

[2] Manager, Water Department, Marshalltown, Ia.

It is this reluctance on the part of the public to believe that any city property, especially a water works system, should ever wear out which has compelled water works managements in many places to put off the evil day of reconstruction as long as possible and then when something must be done to prevent disaster to seek ways and means of getting by as cheaply as possible. The mere thought of a bond issue percipitates a fight and mud begins to fly in all directions, originating in most cases from sources least informed on the subject. Working on the assumption that a small bond issue will be approved more readily by the public than a larger one, the funds if secured at all are usually insufficient and the improvement suffers accordingly. Just how one Iowa city worked out its reconstruction problem might be of some interest.

MARSHALLTOWN RECONSTRUCTION PROGRAM

The city of Marshalltown, Iowa, was compelled to rebuild an original section of its pumping station this last summer. When the Board of Water Works Trustees first took the matter up for consideration it decided that no matter in how dangerous a condition the old building might be, there was little use in asking the public to vote on a bond issue. Every member agreed that, if there was any way to raise the money without a vote of the people, it was the thing to do as they all felt that a bond issue would be defeated. A plan was finally worked out whereby a 2 mill levy authorized by state law and already received by the water department out of city taxes was pledged as security. A total sum of $50,000 was raised for water works improvements by practically mortgaging the water works property and pledging a certain definite source of income as security. No objections were raised to this plan and the bonds were issued and turned over to a bank for safe keeping to be sold only when the money was needed, thereby saving several hundred dollars of accrued interest.

The original water works pumping station at Marshalltown was built in 1876. This portion together with a number of later additions were in very bad shape. The walls were cracking and crumbling and the metal roof was practically eaten away. After careful investigation and study of the old structure it became apparent that a floor space area of 50 feet wide and 130 feet long had to be completely torn down and rebuilt while keeping the pumping units and boiler room in operation.

After deliberation the Board of Trustees decided not to employ an outside architect and instructed its superintendent and general manager to prepare a set of plans and specifications. While investigating the condition of the old foundations and working out desirable changes, the writer became convinced that the probability of uncertain quantities which could not be determined until after the old structure had been torn down would make it extremely difficult to estimate the cost of the improvement. It was likewise believed that a contractor could not prepare an intelligently fair bid and would of necessity increase his estimated bid to take care of uncertainties. In order to insure a good job and at the same time keep the cost within a reasonable limit it was suggested that the work be done on a cost plus basis.

At first the idea of cost plus did not appeal to the members of the water board and one member was very definite in his objections. However, after each member had gone over the prepared plans and were shown the difficulties involved and after it had been pointed out that a limit could be placed on the contractor's plus they unanimously decided that money could in all probability be saved by doing the work on a cost plus basis. A contract was accordingly drawn up to fit conditions, extracts of which are as follows:

The first party (Water Department) agrees to place orders for, buy and pay for all materials necessary for the completion of this work.

The first party agrees to pay second party at the end of each week an amount equal to the second party's weekly payroll, on presentation of an itemized payroll sheet which shall be subject to check and approval by first party's water works manager.

The second party estimates the cost of rebuilding and reconstruction as defined by the plans and specifications at $..... and agrees to tear down the old building and rebuild it and dispose of all rubbish and do all of the work necessary to complete this contract as provided by the plans under the direction of said manager and in such a manner as will not interfere with the operation of the pumping units and boiler plant on a basis of such estimated cost plus $..... for his services and the use of his tools and equipment and it is agreed by the second party that if 10 per cent of the actual cost of material furnished and paid for by first party and labor furnished by second party and paid for by first party is less than the sum last above specified, then second party shall receive and be paid as compensation only 10 per cent of the actual cost. That in any event, the amount received by second party shall not exceed the sum of $..... above specified, notwithstanding the cost of the work, is greater than the estimate of $.....

Bidders blanks were prepared and bids called for. Instead of the contractor entering a bid for the total sum for which he would do the work, he simply stated the amount which he was willing to accept for his services and use of his equipment. A definite sum would be his clear profit in spite of the cost of the job.

Bids were opened on July 6, 1928 with four local contractors bidding. The estimates of the cost of the job ranged from $13,500 to $16,500 and the contractor's compensation from $1200 to $1500. The Board of Trustees considered the bids and awarded the contract to the contractor who they believed to have the best equipment for doing the work and who had also had the most experience. The estimated cost of the successful contractor was $16,000 and his compensation was to be $1275.00.

Active work of tearing down and reconstruction began July 24 and continued until October 1, 1928. A building 50 feet wide and 100 feet long together with a reinforced concrete coal room 25 by 50 and 22 feet high, steel trussed roof spaced 16 feet 10 inches on center, cost a total of $16,756.49. The materials cost $9,263.12 and the labor furnished by the contractor amounted to $3.961.35. Five masons, six carpenters and three laborers were the maximum employees furnished by the contractor at any one time. All the rest of the labor were supplied out of the regular water works employees.

The job progressed rapidly and was completed two weeks earlier than anticipated and a first class job was done in every respect. Marshalltown now has a well built pumping station of which it can be proud at not too excessive a price. There are times when a straight contract has its advantages and is preferable, but when it comes to reconstruction the cost plus basis certainly works. If you have a questionable job, one which involves probabilities of extra quantities and desire first class construction then buy your own materials and guarantee the contractor a definite profit.

HYDROGEN SULFIDE REMOVAL AND WATER SOFTENING AT BEVERLY HILLS, CAL.[1]

By R. L. Derby[2]

The problem of hydrogen sulfide removal from the water supply of Beverly Hills has presented itself in two phases, viz., the removal of the gas from the water and the subsequent removal or dilution of the liberated gas from the air in the vicinity of the water treatment works. While both problems have been solved by the engineers for the city, it is the object of this paper to deal principally with the first phase and merely touch upon the treatment of the air.

The City of Beverly Hills is a strictly residential city of about 13,000 lying some ten miles west of Los Angeles. It has an area of about five square miles with a topography varying from flat, and formerly somewhat marshy land at an elevation of 130 feet above sea level in the south to very hilly country of 800 feet elevation at the northern boundary.

Prior to 1922, the principal supply of water was from wells and some tile drains located in one of the canyons in the north. In periods of heavy demand, these were helped out by pumping some old irrigation wells in what was known as the Cienega basin in the southeastern part of the city. The period of 1920 and 1924 was one of very rapid growth, the population in 1920 being only 700 while by December, 1923, it was about 3000. Due to the type of community, strictly residential with large estates very highly cultivated, the hot weather demand on the water system grew out of all proportion to what might be expected. Average daily summer demands ran as high as 500 gallons per capita with peaks of nearly double this. This is a 100 per cent metered city.

In 1923, the old wells in the Cienega basin were further developed and more put down. Hydrogen sulfide was present in some wells from the start, but not in very large amounts, only 1 to 3 p.p.m.,

[1] Presented before the Water Purification Division, the San Francisco Convention, June 14, 1928.

[2] Sanitary Engineer, Salisbury, Bradshaw and Taylor, Consulting Engineers, Los Angeles, Calif.

and it was hoped that succeeding wells would not average more. Disappointment was met with, however, and of the fourteen wells since developed in this area, all within a radius of one-half mile, only two are entirely free from the gas. In the remainder, H_2S is present in amounts varying from 1 to 20 p.p.m. Methane or marsh gas and free CO_2 are also encountered in the water.

These 14 wells vary from 300 to 450 feet in depth and show a great diversity of chemical content (table 1).

The pH value of the water varies from 7.8 to 8.2 at the wells and increases about 0.2 upon aeration. Free CO_2 runs as high as 30 p.p.m.

TABLE 1

Chemical analyses of the Beverly Hills wells

(Results in parts per million)

CHARACTERISTIC	MAXIMUM	MINIMUM	AVERAGE
Total solids	1,200	520	740
Hardness	480	170	300
Chlorides	250	50	100
Sulfates	170	(trace)	59
Alkalinity	640	300	380
Calcium	84	28	51
Magnesium	69	26	40
Sodium	390	110	185
Flow of wells	540*	135*	300*

* Gallons per minute.

These 14 wells constitute the group known as the sulfur wells and were developed in the period 1924 to 1927 inclusive. They have, during the last year been supplemented by two other wells in another basin whose analysis is comparable, except that they contain no H_2S or methane. This water is now being softened and filtered with the sulfur water as will be described later.

HYDROGEN SULPHIDE REMOVAL PLANT

To take care of the H_2S, an aerator consisting of 30 Sacramento nozzles was put in operation in June, 1924. This plant consisted of a basin 40 by 50 by 7 feet deep under the sprays and a second basin 50 by 30 by 7 feet deep from which pumps took their discharge. The plant was subsequently enlarged by a third basin 90 by 50 by 4 feet deep and 20 more nozzles. The Sacramento nozzles gave a satis-

factory spray from the start, but did not cause a very complete reduction of H_2S. This was probably due to the presence of alkaline sulfides inasmuch as the amount of H_2S in the influent had but slight effect upon the amount after passing the sprays. The time element played the most important part. An inlet water ranging from 6 to 10 p.p.m. of H_2S would show a nearly constant effluent of 3.5 to 4.0 p.p.m. Retention of four hours or longer gave a marked reduction in H_2S. Blowing air through the water gave negative results, except after very long retention. About a month after starting this aerator, a growth of crenothrix was observed and it was necessary to clean the basins. Later in the year the crenothrix gave way to beggiatoa which has since been a constant companion, resisting all methods but very heavy chlorination and mechanical cleansing. Copper sulfate was useless due to the formation of copper sulfide and discoloration of the water.

During the summers of 1924 and 1925, it was this growth which caused most trouble from taste and odors in the water. The aeration plant was not overloaded then and water was retained about two hours and H_2S in the effluent seldom exceeded 1 to 2 p.p.m. In 1926 and after, the retention period of the aerator was reduced during peaks to much less than one-half hour and the H_2S in the effluent ran as high as 2 or 3 p.p.m. In addition, the growths of beggiatoa became so troublesome that it was necessary to clean basins every week or ten days. Fairly vigorous growths in pipes were also observed. A further affliction fell upon the water department in that H_2S producing bacteria became very active so that water in the outlying districts actually contained more H_2S than that leaving the plant. This condition caused much "black water" due to the iron sulfide formed from the H_2S attacking the pipe interior. Needless to say the water department was not kept in ignorance of this trouble.

Chlorination was resorted to in July, 1926, and 400 pounds a day were used. This was at the rate of about 80 or 90 pounds per million gallons. So heavy was the coating of beggiatoa on the transmission mains, that it was a week before free Cl reached more than a block or two from the plant and about a month before it reached a water tower some 7500 feet from the aerator.

Conditions were helped some, but it was impossible to reach the outer districts without causing trouble from an over dose of chlorine close to the plant. In fact, it was necessary later to cut the dose to 50 and still later to 25 pounds per million gallons. This latter amount was necessary to react with the H_2S present in the effluent.

FILTRATION EXPERIMENTS

After the summer of 1926, filtration was looked upon as the only satisfactory solution, but there were many details to work out. An experimental plant of about 70,000 g.p.d. capacity was therefore built and put in operation for three months in the spring of 1927.

This experimental plant consisted of three rectangular basins each holding about four hours flow, two circular mechanical mixing tanks with a ten minute retention period each, two gravity wood filters of 12.5 square feet filter area each, a Gauntt dry feed machine for alum and an aerator of 3 Sacramento nozzles. A home-made wet lime feed, a chlorinator, and a blower for air wash were added later.

The plant was initially started using two basins on eight hours retention after aeration, addition of alum, four hours settling and then filtration. Various rates of mixing speed were used and various alum dosages, but although the effluent was clear and free from H_2S from the very first, the filter runs did not exceed eight hours, the sediment on the filters was very sticky and did not wash off well.

It was now that lime was first seriously considered. For two or three years, there had been some agitation for softened water in Beverly Hills. Due to the fact, however, that in summer over 75 per cent of the water was used for irrigation, it was not considered the best economy to undertake municipal softening. Lime treatment was given consideration now chiefly as an aid in floc building and also as a possibility of reducing the hardness. Lime was first used alone without alum. It was added directly after the sprays. Filter runs at once increased to twelve or more hours. About an 8 or 10 grain per gallon dose was used. Alum was then tried with a dose of 1 grain per gallon and filter runs increased to as high as forty or more hours.

Air wash was also used and the percentage of wash water was reduced from 5 or 6 per cent to 2 to 4 per cent and runs were slightly increased. Chlorination was used but not for a sufficient length of time to notice any definite effect upon the filter capacity. It did however, very definitely clear out the beggiatoa which had become very luxuriant in two months, in a water with a phenolphthalein alkalinity of 20 to 30 p.p.m. At no time did the effluent contain more than 0.8 p.p.m. of H_2S and that only twice. The average was less than 0.4 p.p.m., a blank with distilled water frequently showing half that amount. After reviewing the results of the experimental plant, the engineers decided to include partial softening in the regular operation of the proposed filtration plant.

Various types of spray nozzles were tried out at the experimental plant and tested both for loss of head and efficiency of H_2S reduction at various rates of flow. As a standard, a flow of 55 g.p.m. was taken and all comparisons made at this rate. At this rate the lowest loss of head was 5 feet for the Sacramento nozzle, the next being 12, and from there to 20 or more feet. Hydrogen sulfide elimination ranged from about 50 at this rate for the Sacramento to 63 per cent for other types. Weighing loss of head and H_2S elimination, the Sacramento nozzle showed up the best and was therefore used.

NEW FILTRATION PLANT

The new filtration plant as completed and recently put in operation consists of the following elements.

1. Aeration with 90 Sacramento nozzles. The aerator is housed with a ventilating tower at one corner to conduct H_2S and other gases away. Heat from either gas or oil is used to create a draft and cause good dispersion in air.

2. Coagulation, primary. After leaving the aerator, lime, 10 grains, and alum, 0.5 grain, are added and water is mixed in four basins, 12 feet diameter and 20 feet deep by variable speed, mechanical agitators. The speed varies from 13 to 20 r.p.m. Retention time is five minutes per tank. They may be operated four in series or two groups in series.

3. Clarifier. From the primary tanks, water passes through a 60 foot Dorr traction clarifier with a retention time of one hour.

4. Secondary coagulation. From the Dorr tank, water goes to the secondary tanks, identical in every respect with the primary tanks. A final dose of 0.5 grain of alum is added here and water then goes to the final basin.

5. Final sedimentation basin. This basin is 96 by 130 by 14 feet deep with one around-the-end baffle. The theoretical retention at 5 m.g. is about six hours. A second basin of similar capacity is provided for and will be added when daily flow reaches 7 m.g.d. or more.

6. Filters. These are five in number of two sections 9 by 20 feet or 360 square feet area for each filter. Effective size of sand is 0.40 mm. and uniformity coefficient 1.4. Underdrains are of 2-inch seamless red brass, 9-inch centers with $\frac{3}{8}$-inch holes at 6-inch centers in single row on bottom. Air wash is provided for by a positive pressure blower. Wash water is furnished from two tanks on the fourth floor of the building. The capacity of the tanks is 57,000 gallons each. A total

wash of twenty minutes may be made without refilling. Provision has been made so that 5 additional filter units may be put in, thereby making the ultimate capacity of plant 10 m.g.d. at the standard two gallon rate.

Chlorination is provided for by two vacuum type machines, one to take care of the effluent and the other to dose at any point after aeration. At present it is being used just before filtration. The chlorine room in the building is arranged to be entered from outdoors with a window to the interior of the building.

Lime is fed by one Gauntt dry feed and one International wet feed machine. Alum is fed by two Gauntt dry feeds.

The plant has been in operation only about a month and so no detailed operating figures can be given at present. No H_2S has been detected in the effluent although inlet water shows 6 to 7 p.p.m. No beggiatoa have as yet been observed in the effluent in spite of the heavy growth already occurring in the aerator and other basins.

The water is softened from 40 to 50 per cent from 275 p.p.m. in the raw water to about 160 to 170 p.p.m. soap hardness in the effluent. Lime dosage, after some experimenting, has been set at 10 grains per gallon, or about 6500 pounds daily. Hydrated lime is used and costs $15.70 per ton delivered. Therefore, softening cost is approximately $11.20 per m.g. for lime alone.

It is proposed to conduct some experiments on returning the sludge from the Dorr with a view to obtaining better sedimentation and also a saving in lime consumption.

Since the operation of the plant, there have been many favorable remarks on the improved quality of the water.

PROGRESS IN CHLORINATION OF WATER, 1927–1928[1]

By L. H. Enslow[2]

PRE-CHLORINATION

The practice of applying chlorine to the raw or the coagulated water at some point ahead of the filters has received marked impetus during the past twelve months.

In many instances the sources of raw water supply are becoming so polluted with sewage as to make it impossible to depend entirely on coagulation and mechanical filtration. Pre-chlorination has been effectively applied in several instances to reduce the bacterial load on the filters. Final or post-chlorination has been reduced and, in conjunction with pre-chlorination, can be considered primarily as a factor of safety. Pre-chlorination is receiving increasing attention also because effective purification may be had without the necessity of maintaining residual chlorine in the filtered water to the extent otherwise considered advisable for a high degree of safety. Algae growths, so frequently a disadvantage in coagulation or settling basins, seem to have been effectively reduced or controlled by chlorination of the raw water. Filter runs have been materially increased, wash water consumption reduced, and the general condition of the filter beds has been improved. In at least one instance the filters have produced a sparkling effluent which prior to pre-chlorination could not be procured. Chlorination ahead of the filters is effective in reducing the "slime" on the sand grains and thus the filters are more effectively washed. The occurrence of mud spots, mud balls, and breaks or cracks in the sand bed has been minimized.

With some waters, putrefaction and liquefaction of the deposited sludge in the coagulation basins sometimes results in fouling of the incoming fresh water and eructations of sludge from the bottom of the basins. Pre-chlorination is effective in retarding this putrefactive action; basin washing is cut down and the taste of the water is improved.

[1] Presented before the Water Purification Division, San Francisco Convention, June 14, 1928.

[2] Research Engineer, The Chlorine Institute, Inc., New York, N. Y.

Several instances have been reported in which reduction of coagulant has resulted from pre-chlorination. This advantage, however, can not be predicted unless the water is known to contain iron. An actual trial is necessary to determine in each case what value pre-chlorination as a coagulant-saving process may possess.

Recent pre-chlorination results

It should be pointed out in the beginning that the pre-chlorination data definitely support the conclusions of H. W. Streeter[3] and associates that filters will not produce an effluent meeting the Treasury Department Standard when the raw water contains many more than 60 B. coli per 100 cubic centimeters.

Sandusky, Ohio (Lake Erie water)[4]

O. F. Schoepfle, Chemist in Charge at the Sandusky plant, began pre-chlorination of raw water in May, 1926, with the sanction of the Ohio State Department of Health. Progress reports are included in the 1926 and 1927 Proceedings of the Ohio Water Purification Conferences. The outstanding results include longer filter runs, algae reduction, improved coagulation, reduction of chemical costs and improved filter effluents. Figure 1 graphically presents the bacterial efficiencies secured and figure 3 indicates the maximum B. coli content of the filter effluents with and without pre-chlorination. The reduction in monthly averages for B. coli is of interest, but of greatest interest is the elimination of the spasmodic presence of high coli content in the effluent occurring prior to pre-chlorination as shown in figure 3. This effect is of far greater importance than a reduction of the *average* figures. The average pre-chlorination dosage at Sandusky during 1927 was only 0.37 part per million and no attempt was made to carry residual chlorine through to the filters. Post-chlorination dosage was 0.32 part per million, a total of 0.69 part. For short periods residual chlorine was carried through to the filters without harmful effect. The work is being continued to determine the advisability of maintaining residual chlorine on the filters. During pre-chlorination the filter effluent passed the Treasury Depart-

[3] H. W. Streeter. "Studies of the Efficiency of Water Purification Processes." Public Health Bulletin, No. 172, U. S. P. H. S.

[4] Data from plant reports and published papers analyzed and assembled by H. S. Hutton, Wallace & Tiernan Co., Pittsburgh, Pa.

ment Standards. Post-chlorination merely increased the factor of safety.

Warren, Ohio (Mahoning River water)[4]

P. J. O'Connor, Superintendent of Filtration, began pre-chlorination of raw water at Warren, Ohio, filter plant in July, 1927. De-

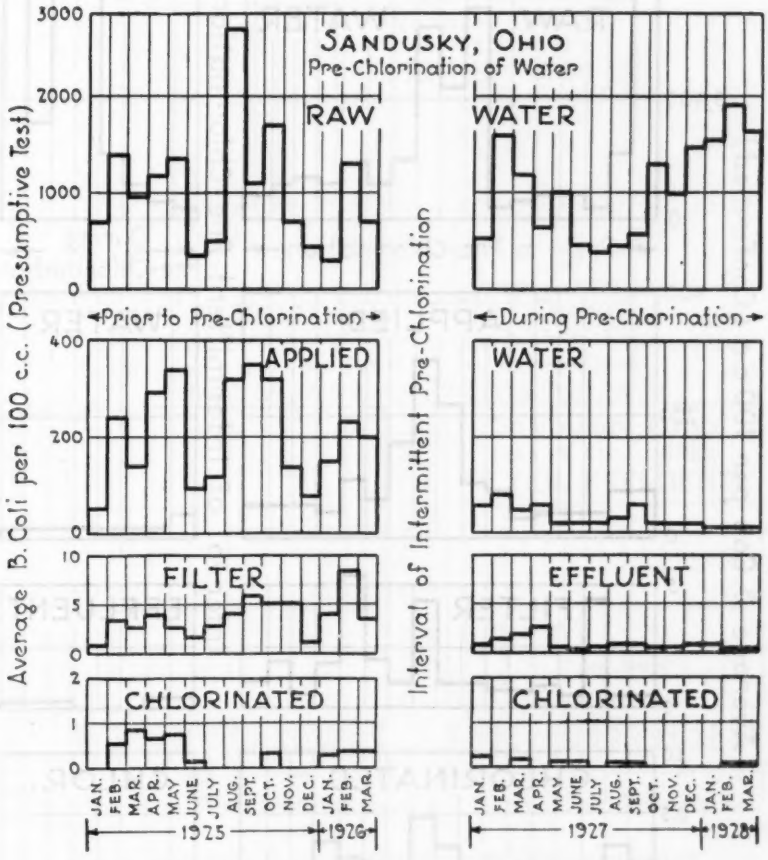

FIG. 1. PRECHLORINATION RESULTS AT SANDUSKY, OHIO

tailed results will appear in the 1927 Proceedings of the Ohio Water Purification Conference. The results indicate the great value of pre-chlorination in plants which must handle a water subject to rapid and wide fluctuations in bacterial content. The benefits derived include a 33 per cent reduction of coagulant otherwise required to re-

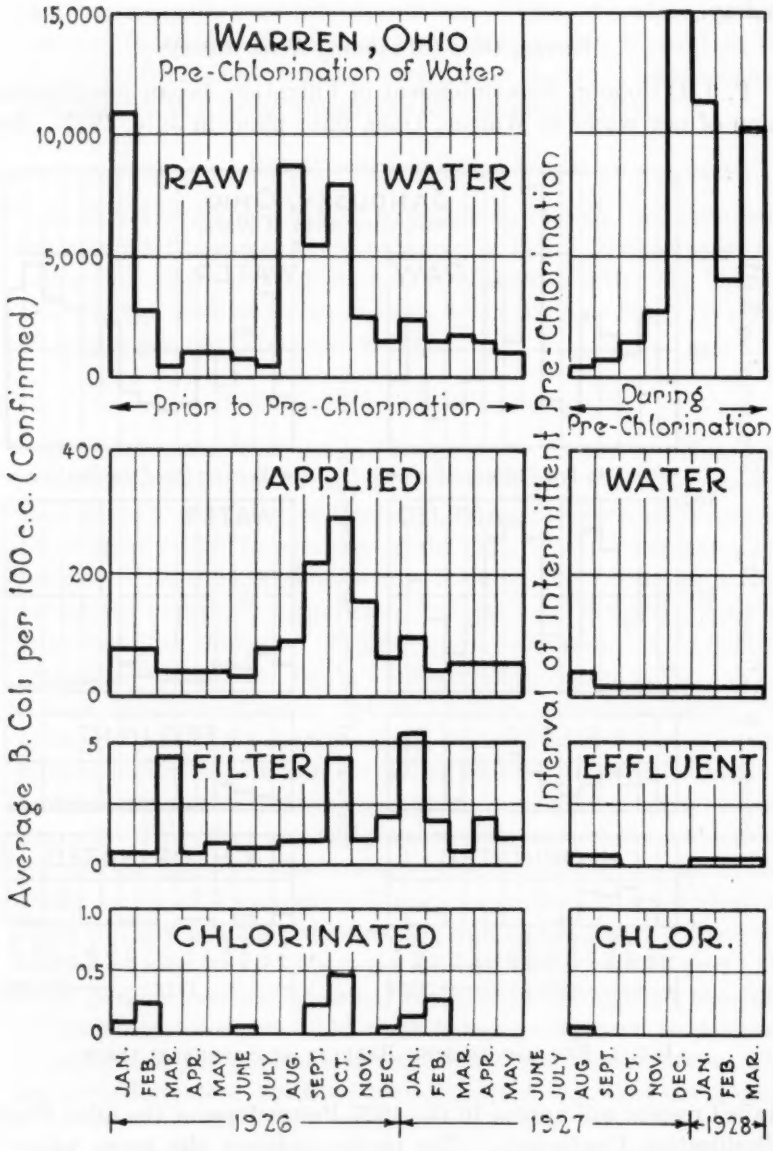

FIG. 2. PRECHLORINATION RESULTS AT WARREN, OHIO

lieve the filters of the high bacterial load, algae reduction, and an increase of approximately 20 per cent in length of filter runs. It has been possible to secure a filter effluent which meets the Treasury Department Standard continuously during pre-chlorination. The pre-chlorination dosage was on the average 0.75 part per million,

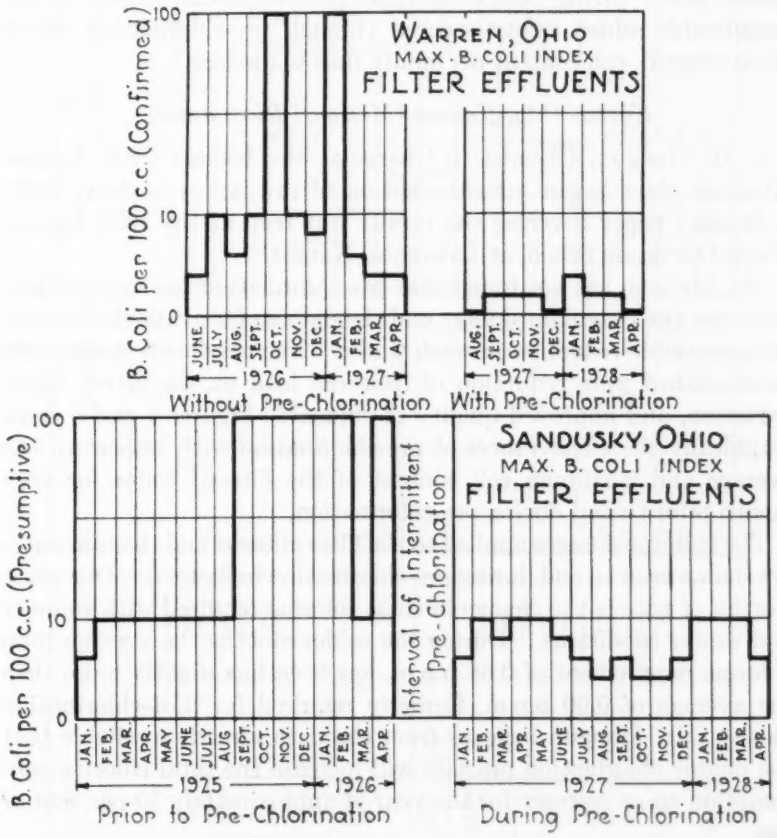

FIG. 3. MAXIMUM B. COLI RESULTS WITH PRECHLORINATION

which produced an applied water on the filters containing from a trace to 0.1 p.p.m. residual chlorine. The post-chlorination dosage has been reduced from the former figure of 0.35 to 0.23 p.p.m., making a total chlorine consumption of approximately 1.0 p.p.m.

Such a reduction in the final chlorine application is of importance at Warren where the water is pumped directly into the distribution sys-

tem. There is now a greater factor of safety and less chance of chlorine tastes appearing in the system.

The bacterial results secured during periods prior to and during pre-chlorination are shown in figures 2 and 3. Figure 3 is of particular interest in that it indicates the maximum B. coli content of the filtered water during each month and presents a fair picture of the considerable added safety secured through pre-chlorination which the average B. coli content per month fails to disclose.

Kansas City, Kansas (Missouri River water)

L. B. Mangun, Chemist in Charge at the Kansas City, Kansas filtration plant began pre-chlorination of raw water in July, 1927. A detailed paper covering the results was read at the 1928 Kansas Water Operators School at Lawrence, Kansas.

Mr. Mangun has not found that pre-chlorination has enabled him to reduce the coagulant dosage and the data so far available indicate no appreciable reduction in wash water. The chief ends sought and accomplished were reduction of bacterial load on the filters, algae reduction, and improved quality of effluent. Figures 4 and 5 show graphically the effectiveness of pre-chlorination with respect to the average and maximum coli content of the filtered water for each month prior to and during pre-chlorination.

The chlorine dosages applied to the filter effluent and the raw water are shown prior to and during pre-chlorination in figure 5. One point worthy of note is the change in total chlorine required with summer and winter conditions. During the colder months the average total chlorine requirement of 0.68 p.p.m. has been but slightly more than the average of 0.60 p.p.m. formerly required for post-chlorination alone. Mr. Mangun believes from the data already available that the double chlorination practice will increase the total chlorine consumption on an average for the year of approximately 50 per cent or less.

During the summer months no residual chlorine reached the filters when the pre-chlorination dosage averaged from 1 to 1.33 p.p.m. During the winter with dosages of 0.34 to 0.49 p.p.m. residual chlorine reached the filters and occasionally appeared in the effluent without harmful effect to the filters having been observed.

An important feature has been the reduction of the residual chlorine maintained in the final water following post-chlorination with continued satisfactory sterilization insured. Prior to pre-chlorina-

tion a residual of 0.2 p.p.m. was maintained whereas during pre-chlorination 0.08 p.p.m. has been satisfactory, primarily because less dependence on post-chlorination is necessary during double chlorination.

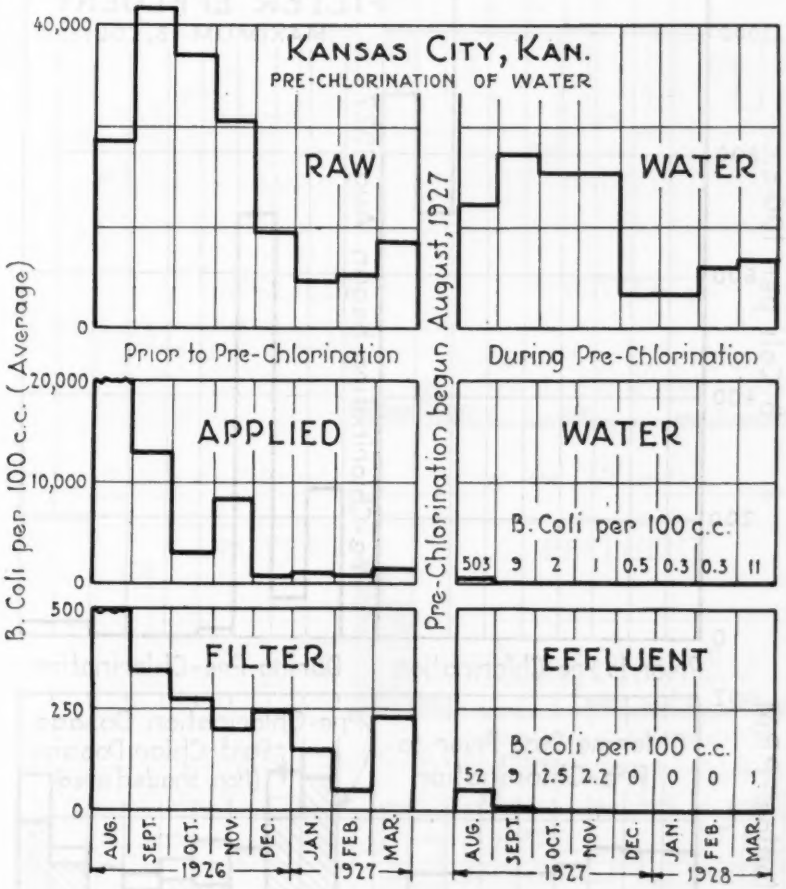

FIG. 4. PRECHLORINATION RESULTS AT KANSAS CITY, KAN.

At Kansas City, Kansas, with single chlorination the cost has been 43 cents, and with double chlorination, 65 cents per million gallons.

Hopewell, Virginia (James and Appomatox Rivers water)

Richard Messer, Chief Engineer, Virginia State Department of Health, has analyzed the data and supplied graphs of the results at

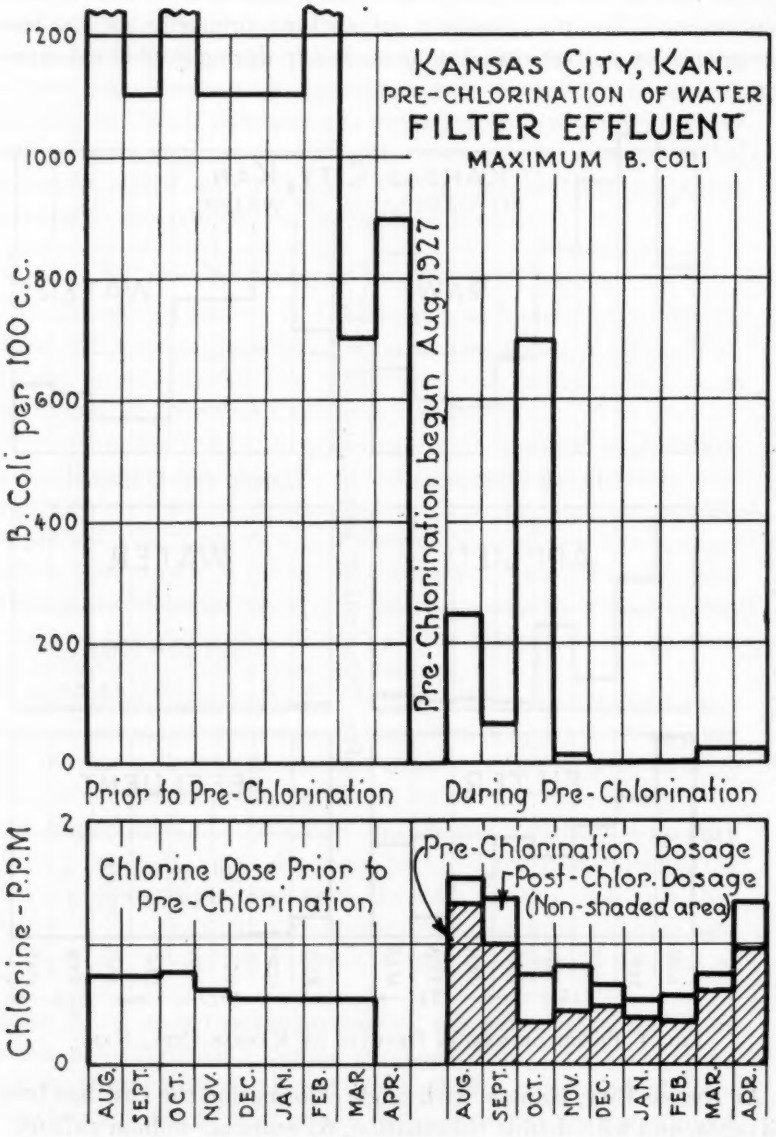

FIG. 5. MAXIMUM B. COLI RESULTS AT KANSAS CITY, KAN., BEFORE AND AFTER PRECHLORINATION

the Hopewell filtration plant where J. W. Haller, Chemist in Charge of the filtration plant began pre-chlorination of the raw water early in 1924. (See figure 6.)

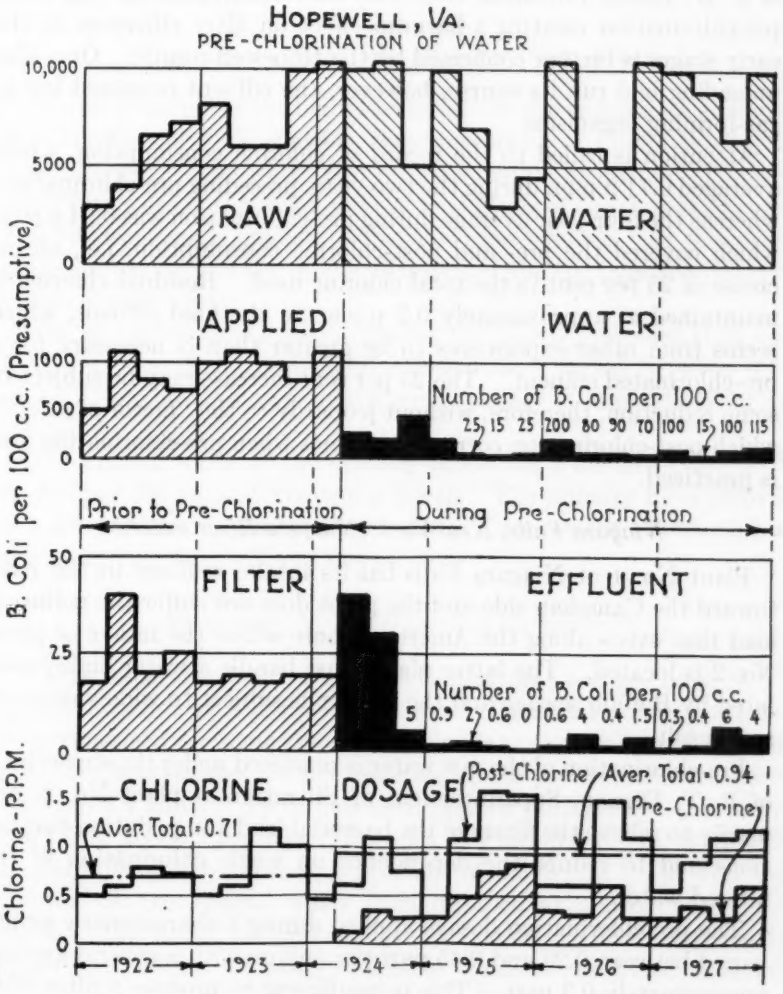

FIG. 6. PRECHLORINATION RESULTS AT HOPEWELL, VA.

The first effect of pre-chlorination was not beneficial to the filter effluent, although a marked reduction in B. coli content of the applied water was promptly secured. During the first few months of pre-

chlorination the filters seemed to be unloading gas-producing organisms (presumptive B. coli) and the effluent was inferior in this respect to that prior to pre-chlorination. The observations and statements of J. W. Ellms, Filtration Engineer, Cleveland, Ohio, in respect to pre-chlorination exerting a harmful effect on filter efficiency in the early stages is further confirmed by the Hopewell results. Once this unloading had run its course, however, the effluent remained low in gas-forming organisms.

Attention is called to the record of chlorine consumption, which averaged 0.71 p.p.m. during the two years preceding pre-chlorination, whereas the four-year average during pre-chlorination was 0.94 p.p.m. which covered the pre- and post-chlorine consumption, i.e., an increase of 25 per cent in the total chlorine used. Residual chlorine is maintained at approximately 0.2 p.p.m. in the final effluent, which seems from other experiences to be greater than is necessary for a pre-chlorinated effluent. The 25 per cent increase may be subject to some reduction, therefore, without jeopardy to the "factor of safety" which post-chlorination correctly assumes when pre-chlorination also is practiced.

Niagara Falls, New York (Niagara River water)[5,6]

Plant No. 1 at Niagara Falls has its intake well out in the river toward the Canadian side and the plant does not suffer the pollution load that exists along the American shore where the intake of plant No. 2 is located. The latter plant must handle a water highly polluted by Buffalo sewage and the quality is subject to wide variations as a result.

Pre-chlorination of the raw water is practiced under the supervision of B. T. Dignan, Superintendent of Filtration at plant No. 2, primarily to relieve the filters of the bacterial load and pollution fluctuations and to reduce the dependence on single chlorination of the filtered water.

The pre-chlorination dosage applied during a characteristic month varied between 0.23 and 0.45 part per million with a general average approximately 0.3 part. This is insufficient to produce a filter effluent which will meet the Treasury Department Standard and post-

[5] Data from plant reports analyzed and assembled by C. R. Cox, Assistant Engineer, New York State Department of Health, Albany, N. Y.

[6] C. R. Cox. "Double Chlorination." Jour. A. W. W. A., 16:1:55, July, 1926.

chlorination is at all times essential. The final chlorination averages approximately 0.2 p.p.m. which, without pre-chlorination, would necessarily be greater to insure safety when dealing with such heavily polluted raw water.

Poughkeepsie, New York (Hudson River Water)[5,6]

Pre-chlorination of the highly polluted raw water is practiced under the direction of F. T. Lawlor, Superintendent of Public Works, at Poughkeepsie. The water also receives double filtration. The primary filters are of the rapid and the final filters of the slow sand type. Post-chlorination is applied to the slow sand effluent. At this plant pre-chlorination and the double filtration make the final chlorination purely a safety factor.

The pre-chlorination dosage during 1927 varied between 0.56 and 0.70 p.p.m. and the post-chlorination dosage varied between 0.13 and 0.22 p.p.m. making a total average dosage of approximately 0.8 p.p.m.

The applied water at the primary filters has a median value of 10 B. coli per 100 cc. and frequently lower. The primary filter effluent will not continuously meet the Treasury Department Standard, but the secondary filter effluent does.

Rensselaer, N. Y. (Hudson River water)[5,6]

Under supervision of J. M. Caird, Consulting Chemist, Troy, N. Y., pre-chlorination of the raw water at the Rensselaer filter plant has been practiced for some time. At this plant the heavy pollution of the river necessitates heroic measures and a pre-chlorine dosage of between 1.4 and 1.9 p.p.m. has been applied during 1927—the average being about 1.5 p.p.m. Between 0.4 and 0.6 p.p.m. is applied to the effluent to maintain a residual of 0.2 p.p.m. The residual chlorine in the applied water is maintained at approximately 0.5 p.p.m. The heavy residual chlorine carried on the filters apparently keeps the beds in an easily washable condition and free of slime, mud accumulations and bed growths. Post-chlorination does not seem to be essential, but is continued as a factor of safety because of the considerable dependence on chlorination to produce a safe water at the Rensselaer plant.

Rochester, N. Y. (Lake Ontario water)[5,6]

At the filtration plant of the Rochester and Lake Ontario Water Company, J. F. Amos, Chemist, practices pre-chlorination of the raw water and secondary chlorination of the applied water ahead of pressure filters. The operation is under the supervision of J. M. Caird, Consulting Chemist, Troy, N. Y.

The raw water is subject to a variable intensity of pollution and organic content, which prior to pre-chlorination made it difficult to insure effective sterilization by single chlorine application. At present the major sterilization is secured through pre-chlorination and a minor secondary dosage renders the maintenance of residual chlorine in the final effluent relatively simple. But slight residual is thus required and in connection with the lake water of normally low organic content the low residual chlorine maintained makes the water less liable to chlorinous tastes and odors.

During the period March, 1927 to February, 1928, the pre-chlorine dosage varied between 0.20 and 0.67 p.p.m. and the secondary application to the applied water varied between 0.03 and 0.13 p.p.m. The median figure for the total chlorine applied was approximately 0.32 p.p.m.

Raleigh, N. C.

J. S. Whitener, formerly Superintendent of Filtration at Raleigh, N. C., and now Assistant Engineer of the North Carolina State Department of Health, reports further progress in pre-chlorination at the Raleigh filter plant.

Mr. Whitener[7] read a paper at the 1927 meeting of the North Carolina Section of the American Water Works Association which gave an account of the results following chlorine application to the applied water ahead of the filters. An earlier experiment with pre-chlorination of the raw water had not shown any marked improvement in conditions whereas the application to the coagulated and settled water gave a very apparent improvement in the condition of the filter beds and eliminated the "murkiness" previously possessed by the effluent. Simultaneously the bacterial quality was improved, and the wash water was reduced. Mr. Whitener now reports

[7] J. S. Whitener. "Pre-Chlorination at Raleigh, N. C." Jour. North Carolina Section, A. W. W. A., Vol. 5, (1927), p. 101. Water Works, December, 1927, p. 504. American City, May, 1928. Jour. A. W. W. A., 20:1:61, July, 1928.

further data and continued success. The comparison of the average length of filter runs prior to pre-chlorination (1927) and the same months during pre-chlorination (1928) follows:

Raleigh, N. C.—Average hours filter runs

MONTH	PRIOR TO PRE-CHLORINATION 1927	DURING PRE-CHLORINATION 1928	PER CENT INCREASE
January	24	37.5	56.2
February	24	43.6	81.6
March	29	42.5	46.5
April	24	42.4	76.7

The filter beds continue to remain in the improved condition secured following introduction of pre-chlorination. The wash water has been reduced more than 50 per cent. The filter effluent shows no B. coli and the total bacteria average less than 0.5 per cubic centimeter. The water in the clear water basin continues to remain clear and sparkling at all times which was not the condition prior to pre-chlorination.

The pre-chlorine dosage over the period January to April, 1928, has averaged 0.32 p.p.m. and post-chlorine dosage 0.16 p.p.m., making the total consumption 0.48 p.p.m. whereas with final chlorination only, during the same period in 1927, it averaged 0.36 p.p.m., an increase of but 0.12 p.p.m. Residual chlorine of approximately 0.2 p.p.m. is carried on the filters, but this completely disappears during passage through the sand bed and no residual is found in the effluent.

Southern Pines and Fayetteville, N. C.

Mr. Whitener reports that the recent experimental pre-chlorination of the raw organically stained waters at the filtration plants at Southern Pines and Fayetteville indicates that superior coagulation and greater color removal have been secured during pre-chlorination. Simultaneously the filter runs have increased. The State Department of Health has recommended that pre-chlorination be adopted at both plants.

Toronto, Ontario: (Lake Ontario Water)

N. J. Howard, Bacteriologist in Charge, Toronto Filtration Plant, reports that during super-chlorination, when pre-chlorination is discontinued, the rapid sand filter effluent becomes slightly turbid and

the amorphous matter and bacterial content of the effluent increase preceptibly. In Howard's opinion "pre-chlorination of water, which is non-susceptible to taste production, is at all times beneficial in a physical as well as bacteriological sense."

Chester, Pa. (Delaware River water)

Lyle L. Jenne, Chemical Engineer, Chester, Pa., in charge of the Chester filtration plant, reports that pre-chlorination of the raw water was initially practiced to secure elimination of foreign tastes and odors which previously appeared intermittently in the filtered water. The raw water was tested daily to ascertain whether pre-chlorination would improve the taste or odor and the process applied during such periods as the tests indicated it to be of advantage. During the past three years this intermittent practice has been successfully employed. Recently the chlorination capacity has been increased and now continuous pre-chlorination is also employed to reduce the bacterial load on the filters. Publication of data is not warranted because of the limited period during which continuous pre-chlorination has been in use at the Chester plant.

Philadelphia, Pa. (Schuylkill River water)

Lyle L. Jenne, Chemical Engineer of the Bureau of Water, Philadelphia, Pa., in charge of the water purification plant, began pre-chlorination of the raw water at the Queens Lane rapid sand filter plant in November, 1927, primarily for the purpose of reducing the bacterial load on the filters. How well this has been accomplished is shown by the following data.[8]

Philadelphia, Pa.—Queen Lane Rapid Sand Filters
(B. coli per 100 cc. in applied water)

	1927 NO PRE-CHLORINATION	1928 PRE-CHLORINATION	PER CENT REDUCTION
January	1,540	19	98.5
February	1,640	410	76.0
March	2,250	10	99.5
April	2,230	10	99.5
November*	850		
December	16		

* Pre-chlorination begun November 6, 1927.

[8] Courtesy Lyle L. Jenne, Chemical Engineer, Chester, Pa.

Baltimore, Md. (Gunpowder River impounded water)

James W. Armstrong, Filtration Engineer, Bureau of Water Supply, Baltimore, Md., has forwarded a brief statement concerning pre-chlorination of the raw water at the Montebello Filters during the Summer of 1927.

During 1926 the raw water contained biological growths and algae to an extent that caused serious shortening of filter runs and necessitated frequent "jolting" of the filter beds with wash water. Finally it became necessary to wash all of the sand in the filters with Nichols machines.

Beginning May, 1927, pre-chlorination was introduced and Mr. Armstrong has supplied a statement to the effect that "no difficulty with the filters was experienced and the Montebello Filters were able during 1927 to keep up to the increased summer demands without difficulty. The general opinion points to a real advantage from pre-chlorination which will further be substantiated or disproved during continuous pre-chlorination throughout the present (1928) summer." Data from the 1927 operations are therefore withheld.

SUPER- AND DE-CHLORINATION AT TORONTO—(NORMAN J. HOWARD[9])

Super-chlorination of the City of Toronto water followed by de-chlorination with sulphur dioxide, for taste prevention, was inaugurated in the fall of 1926 and continued for a period of three months. In March, 1927, because of recurrent tastes, instructions were received to resume treatment as soon as possible. In June, 1927, five new machines were added to existing equipment. The available apparatus at this time consisted of eleven Wallace & Tiernan machines of 300 pounds capacity, seven machines being used for chlorination and four for applying sulphur dioxide for de-chlorination. This equipment has since been increased and at the present time consists of fourteen machines, each machine having a 300 pound capacity per 24 hours. Provision is to be made in the near future for the use of one ton chlorine containers thereby reducing the cost of chlorination to approximately one-half the figures reported herein.

Laboratory experiments previously published[10] showed that taste

[9] Bacteriologist in Charge, Toronto Filtration Plants, Center Island, Toronto, Can.

[10] N. J. Howard and R. E. Thompson. "Chlorine Studies and Observations on Taste Producing Substances in Water and Factors in Treatment by Super- and De-Chlorination." Jour. N. E. W. W. A., No. 3, 1926; Canadian Engineer, October 19, 1926.

in Lake Ontario water, caused by the formation of substitution compounds of phenolic and unknown origin occurring in the presence of chlorine, could be prevented by the application of large doses of chlorine. The amount of this reagent was computed at 1.2 parts per million. As the water became colder in the winter months chlorine had to be increased to 2.0 parts. In actual operation covering a continuous period of eleven months from June, 1927, to May, 1928, the chlorine dosage has occasionslly been increased to 2.5 parts per million.

The treatment of the water for taste prevention is intermittent and is dependent upon the prevailing wind direction. Frequent laboratory tests are made during day and night, the ammoniacal nitrogen test being the index of probable taste production. As the ammonia increases the chlorine dose is raised until the maximum dose is reached. As soon as the laboratory figures show a reduction to normal conditions as judged by chemical tests the chlorine is cut down to the usual dose. The de-chlorinating dose is regulated by ortho-tolidin tests made on the water as it enters the distribution system.

During a 334-day period the treatment was used on whole or in part of 167 days. Not a single taste complaint was filed during the period of super-chlorination. On one occasion, due to faulty operation, the chlorine dose was not increased according to instructions and a distinct taste occurred in the downtown area. Within one hour after increasing the chlorine dosage the water was free from taste.

The importance of complete removal of the residual chlorine, particularly in water susceptible to taste production cannot be overemphasized. Our experience has shown, that taste will only occur in a water which normally would have developed taste following the application of a dose of chlorine. In other words, non-susceptible water which might be super-chlorinated will not give a post-treatment taste if a slight excess of chlorine is left in the water. From a safety point of view residual chlorine is not needed in water which has been super-chlorinated.

The plans for the new one hundred million gallon mechanical plant for Toronto make full provision for super- and de-chlorination treatment and include provisions for the use of one ton chlorine containers and evaporators. This section of the plant when installed will be the most complete and modern in North America.

Table 1 below shows the chlorine and sulphur dioxide dosages. Table 2 shows operation and chemical costs during 1927 and 1928.

TABLE 1

Toronto, Can.—Maximum, minimum and average dose of chlorine, together with maximum and average amounts of sulphur dioxide in parts per million

MONTH	CHLORINE						SULPHUR DIOXIDE	
	Slow sand plant			Drifting sand plant			Dechlorinating plant	
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Average
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
June, 1927	1.2	1.0	0.60	1.8	1.0	0.72	1.5	0.459
July	1.5	0.8	0.68	1.8	0.8	0.76	1.5	0.512
August	1.5	1.0	0.74	1.8	1.0	0.85	1.3	0.526
September	1.5	1.0	0.82	1.8	1.0	0.96	1.4	0.634
October	1.5	1.0	0.65	2.0	1.2	0.69	1.6	0.450
November	1.8	1.0	0.65	2.5	1.2	0.73	1.4	0.441
December	1.8	1.2	0.64	2.2	1.3	0.69	1.6	0.418
January, 1928	1.8	1.5	0.514	2.2	1.5	0.58	1.6	0.336
February	1.8	1.5	0.769	2.2	1.5	0.921	1.6	0.624
March	2.2	1.5	0.975	2.4	1.5	1.17	1.8	0.832
April	2.2	1.5	0.941	2.4	1.5	1.05	2.0	0.745
May	1.5	1.5	1.8	1.5	1.5	0.447	1.2	0.315

Note: The average amount of chlorine applied when superchlorination was not being practiced varied between 0.30 and 0.45 part per million.

TABLE 2

Toronto, Can.—Showing maintenance and operation cost figures, June, 1927 to May, 1928

Chlorine, 94.95 tons	$13,231.57
Sulphur dioxide, 67.28 tons	13,519.60
Labor, 8 men	13,609.20
Maintenance and incidentals	3,000.00
Total	$43,360.37

Note: Cost of chlorine during this time was $139.50 per ton. Price of liquid sulphur dioxide in 1927 was $225 and in 1928 $162.33 per ton. Cost of chlorine in 1928 is $149.50, but the use of one ton containers will reduce the figure by approximately half. The "averages" above are not representative of the chlorine used for super-chlorination. The maximum and minimum figures are representative of the variations during super-chlorination only.

Summary

1. The average amount of water treated from June 13, 1927, to May 13, 1928, was 74.78 million imperial gallons daily.

2. The maximum dose of chlorine applied during the super-chlorination period was 2.5 and the minimum 0.8 p.p.m.

3. The maximum and minimum dose of sulphur dioxide was 2.0 and 0.8 p.p.m. respectively.

4. The treatment was completely successful and a tasteless water was furnished to the consumers.

5. Super-chlorination provides a very high factor of safety.

6. The additional cost incurred by super-chlorination was approximately $0.78 cents per million imperial gallons, $0.96 per million being the cost during ordinary chlorination.

7. The combined cost for sterilization and taste prevention treatment involved in maintenance and operation was $43,360,37, equivalent to $1.74 per million imperial gallons, which is subject to material reduction through purchase of chlorine in one ton containers.

AMMONIA OR PERMANGANATE IN CONJUNCTION WITH SINGLE OR DOUBLE CHLORINATION

Very probably there are instances in which ammonia, ammonia salts or permanganate treatment in conjunction with chlorination, for the purpose of taste prevention, have been applied which have not come to the attention of the author. The limited number of installations on which data have been supplied will be reviewed without intent to ignore other cases.

London, England

Sir Alexander Houston, Director of Laboratories, Metropolitan Water Board, London, England, has supplied the author with the statements given below.

The following taste prevention measures are compared. (Note: The statements in quotation marks are actually those of Sir Alexander Houston taken from a recent communication to the author.)

1. Pre-ammoniation
2. Chloramines
3. Permanganate
4. Super- and de-chlorination

"The conditions under which chlorination has to be applied vary so greatly that it is not possible to lay down any hard and fast rule as to which of the above expedients is the best."

1. "In the case of pre-ammoniation, it is *essential* that the ammonia or ammonia salt be added to the water and thoroughly mixed with it *before* the chlorine is applied."

2. "The use of chloramines has the advantage of requiring but one point of application, but has the disadvantage that some of the chlorine required is lost in the reaction with the ammonia and the yield of chloramine does not seem to be quantitative. Di-chloramine appears to prevent the formation of tastes and sterilizes as well or slightly better than an equal dosage of chlorine."

"The Hampton (Kew Works) experiments go to prove that a simple chloramine process, i.e., mixing chlorine solution and ammonium chloride in solution in molecular proportions is practicable. In dilute solutions similar to those used in simple chlorination at least 75 per cent yield of chloramine is to be expected."

3. "Permanganate has the advantage of being capable of being applied either before, after, or simultaneously with the chlorine. A few experiments indicate relatively large dosages are required, but generally speaking it has proved effective in dosages of 0.24 to 0.96 p.p.m. It has the disadvantage of imparting color to the water, and therefore cannot be used successfully with waters of high organic purity."

4. "Super- and de-chlorination is perhaps the most definite in preventing tastes and for producing rapid and effective sterilization. The process is perhaps best applicable to waters of high organic purity."

For details concerning the Metropolitan Water Board large scale practices with pre-ammoniation and permanganate treatment the reader is referred to the 20th and 21st Annual Reports of this Board.[11]

In treating the New River water, during the winter months only, the supply receives pre-ammoniation continuously and permanganate of potash in addition whenever there is a probability that tastes may develop. Ammonia salts are applied at a point approximately 1 mile ahead of the chlorination and at a rate to provide 0.25 p.p.m. (NH_3) content. Occasionally permanganate is also applied at the

[11] Sir Alexander Houston. 20th and 21st Annual Reports to The Metropolitan Water Board, London, England.

chlorination station at a rate of 0.2 p.p.m. $KMnO_4$. Chlorine is applied at an average rate of 0.33 p.p.m. The treatment has met with complete success at a total chemical cost of 41 cents per million gallons.

At Hampton (Thames River) when the chlorine dosage was constant at 0.33 p.p.m., and ammonia was applied intermittently at a rate of 0.25 p.p.m. (NH_3), the results on the ammonia days showed that only one-half the number of samples contained B. coli an 100 cc. portions compared with the number of 100 cc. portions showing B. coli on days of chlorination without pre-ammoniation. The contact period available prior to sampling, however, was 6 hours, which period is essential to secure the full effect when ammonia is applied, unless the chlorine dosage can be increased.

Sir Alexander Houston in his various reports shows that use of chloramine, or pre-ammoniation, with chlorination requires a period of 4 hours if the most economical dosage of chlorine is to be effective. The contact period may be materially shortened by increasing the chlorine dosage.

In large scale experiments on the Thames water at the Kew Works the di-chloramine process of Harrold, (i.e., mixing chlorine water and ammonia solution or solution of ammonia salts in the ration of 8 chlorine to 1.2 parts NH_3 prior to introduction into the water) was applied. On alternate days chlorine alone was applied and the results compared. With equal chlorine dosages after 6 hours contact the results were the same for chlorine as for di-chloramine, but after 32 hours the chloramine results were superior.

If, as seems to be shown by the Metropolitan Water Board large scale experiments, the di-chloramine process effectively sterilizes and prevents taste production, this process will be more attractive than pre-ammoniation from a cost standpoint.

The costly element is the ammonia and therefore the ratio of 1.2 NH_3 to 8 chlorine to produce di-chloramine is more attractive than the use of more ammonia in pre-ammoniation followed by less chlorine. For example:

Ammonia (NH_3) at 15 cents per pound
Chlorine (Cl_2) at 8 cents per pound

a. Dichloramine (1.2 NH_3:8 Cl) (chlorine 0.5 p.p.m.):
0.5 p.p.m. chlorine
0.07 p.p.m. ammonia
Cost per million gallons—42 cents

b. Pre-ammoniation (chlorine 0.33 p.p.m.)
0.33 p.p.m. chlorine
0.25 p.p.m. ammonia
Cost per million gallons—53 cents

c. Pre-ammoniation (chlorine 0.5 p.p.m.)
0.5 p.p.m. chlorine
0.25 p.p.m. ammonia
Cost per million gallons—65 cents

Greeneville, Tenn. (Softening plant)

Advice from J. W. McAmis, Superintendent of Water Commission, at Greeneville, Tenn, is to the effect that pre-ammoniation of the raw water at the rate of 0.25 p.p.m. ammonia and chlorination of the filter effluent continues to prevent taste development in the distribution system. The original report by McAmis[12] and a subsequent paper by the author[13] contain detailed information concerning the process.

PERMANGANATE-CHLORINE APPLICATIONS

Rochester, N. Y. (Lake Ontario water)[5]

Under the supervision of J. M. Caird, permanganate treatment of the raw water at the plant of the Rochester and Lake Ontario Water Company was begun in January, 1927, as a taste prevention measure. Apparently this is the first instance in America where the permanganate has been continuously applied. After more than a year of operation the permanganate treatment seems to be entirely effective in conjunction with pre-chlorination followed by secondary chlorination.

The permanganate is applied to the raw water almost simultaneously with the pre-chlorine application. The application is controlled by carefully watching changes in chlorine demand of the raw water. Increased demand indicates increasing organic content of the water which in turn indicates that polluted waters of the Genesee River are reaching the intake. This is a signal to begin permanganate treatment and to boost the pre-chlorine dosage to secure desired results. Change of winds which drives polluted water away from the vicinity of the intake allows for discontinuance of per-

[12] J. W. McAmis. "Prevention of Phenol Tastes with Ammonia." Jour. A. W. W. A., 17:3:341, March, 1927.

[13] L. H. Enslow. "Recent Advances in Controlling Chloro-Tastes and Algae Development." Jour. A. W. W. A., 18:5:621, November, 1927.

manganate treatment, but a careful watch is always maintained to detect approach of the taste producing waters.

Table 3 indicates the periods of permanganate application and the rates applied.

Permanganate of potash in commercial grade costs from 18 to 20 cents per pound and may be fed from dry feed machines or solution tanks. The maximum cost for permanganate treatment at Rochester is 23 cents, and the median cost has not exceeded 15 cents, per million gallons.

TABLE 3

Rochester, N. Y.—Permanganate treatment and double chlorination

MONTH	$KMnO_4$		Remarks
	Median	Maximum	
	p.p.m.	*p.p.m.*	
March, 1927	0.08	0.08	Applied 12 days
April	0.06	0.09	Applied 15 days
October*	0.07	0.12	Applied 16 days
November	0.04	0.04	Applied 1 day
December	0.09	0.13	Applied 15 days
January, 1928	0.05	0.14	Applied 11 days
February	0.05	0.13	Applied 17 days

* None applied between April and October.

Buffalo, N. Y. (Western New York Water Company—Lake Erie water)[5]

The raw water is fouled by coke plant wastes which intermittently reach the intake. The only measure of purification is single chlorination which must necessarily be maintained at a relatively high rate.

H. F. Huy of the Western New York Water Company, a pioneer in chlorination of water, started permanganate application on January 16, 1928. The initial rate was but 0.03 p.p.m. which was thereafter varied to suit conditions as indicated in the tabulated data following:

Western New York Water Company, Buffalo, New York, permanganate treatment

MONTH	$KMnO_4$			CHLORINE		RESIDUAL CHLORINE
	Minimum	Maximum	Average	Minimum	Maximum	
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
January, 1928	0.03	0.03	0.03	0.23	1.40	0.2±
February	0.03	0.03	0.03	0.25	0.34	0.2±
March	0.02	0.48	0.03	0.19	2.10	0.2±
April	0.03	0.08	0.04	0.29	0.50	0.2±

In March, serious pollution reached the intake as is evidenced by the high chlorine demand and permanganate required. Nevertheless it was possible to sterilize the water effectively without taste production. Apparently no complaints have been received relative to permanganate strains in the water. The particular interest here lies in the fact that chlorination has been called on to function along where a filtration plant for some time has been considered desirable and is at this writing under construction. The results of the past season have shown what can be accomplished in chlorination of an unfiltered polluted water as a temporary expedient until more adequate purification measures can be secured.

Rensselaer, N. Y. (Hudson River water)[5]

Experiments at the Rensselaer filtration plant during the past winter indicated permanganate application to the raw water effectively prevented taste production, and it will be again experimentally applied should phenol wastes become troublesome.

CHLORINE IN ALGAE CONTROL

Chlorine will probably not supplant copper sulphate as an algaecide, but it is becoming increasingly evident that it has a place in the field of algae elimination and has peculiar advantages in some instances that render it more desirable than copper sulphate. One, for instance, is the accuracy of application to a flow of water past a given point, and another is the additional advantage which chlorination possesses,—i.e., simultaneous sterilization and oxidation. The cost of chlorine is considerably less than that of copper sulphate and there is no cause for controversy in case some of the chlorine remains in the treated water.

The experiences of L. B. Mangun, Superintendent of Filtration, Kansas City, Kans., in the matter of algae control in a distribution reservoir wherein chlorination was employed in a novel manner will be thoroughly covered in a paper on the subject to be read at this meeting. Therefore, the reader is referred to Mr. Mangun's paper for the details and results secured.

New York City, N. Y.

Frank E. Hale, Director of Laboratories, Department of Water Supply, New York City, and also in charge of chemical treatment of the various water supplies of the city, has placed at the disposal of the author the following data on chlorine as an algaecide.

Chlorine dosage of 0.3 p.p.m. applied to the New York water supply attacks microscopic organisms and sets free the distasteful oils from several varieties of algae. Additional chlorine applied destroys the taste thus produced.

A dosage of 0.5 to 0.7 p.p.m. has destroyed and rendered tasteless 100 units of synura and above 0.7 p.p.m. 200 units can be handled. A growth of uroglena (2000 units) has been killed and taste destroyed with 0.5 p.p.m. chlorine, and dinobryon (500 units) has been destroyed and deodorized by 0.5 p.p.m. chlorine. The same dosage given a water entering a storage reservoir caused a 25 per cent reduction of organisms during storage, whereas previously there had been a considerable increase. The organisms offering reduction included asterionella, anabaena, aphanizomenon, coelosphaerium, tabellaria, melosira, volvox, and ceratium.

During the year 1927, chlorination of the New York Water Supply has controlled organisms and tastes as follows:

	DOSAGE	RESIDUAL
	p.p.m.	*p.p.m.*
Synura (3 to 4 units)	0.3	0.05
Asterionella (1350 units)	0.7	0.2
Synura (Croton supply)	0.55	0.1
Synura (Long Island Ponds)	0.3–0.5	0.1

In the well water supply of the Jamaica Water Company crenothrix caused complaints. It was effectively killed in the system by a dosage of 0.5 p.p.m. (residual 0.1 to 0.3 p.p.m.) and blown off at the hydrants.

It is sometimes the case that organisms are killed and taste increased as a result of small chlorine dosages, but for some reason the taste and odor dissipate during the passage of the water through the aqueduct and revervoirs.

Mexia, Texas (limestone springs and deep wells)

At Mexia, Texas, R. D. Morgan, Superintendent of Water Works, employs continuous chlorination almost solely as a means of algae growth prevention in service reservoirs. After various experimental applications Mr. Morgan advises that for best results the following procedure seems to be the most effective. Chlorine (about 0.72 p.p.m.) must be applied to the incoming water *not less than* 20 feet ahead of a baffled mixing chamber constructed at the reservoir. At the mixing chamber inlet, roughly 1.12 grains per gallon of hydrated lime are added. The effluent which enters the reservoir along one side near the surface creates currents which produce a very fair distribution of the incoming water containing 0.3 to 0.5 p.p.m. residual chlorine. Copper sulphate is occasionally applied to dead spots in the corners of the reservoir.

Prior to chlorination the Mexia reservoir was subject to rapid increases in algae growths after each cleaning and, in addition to the use of copper sulphate, in hot weather, weekly cleanings were necessary. After each copper treatment the water was filled with dead and decomposing algae which resulted in considerable complaint and damage at bottling works, laundries, etc.

Chlorination has been in use for almost two years and in a recent letter Mr. Morgan makes the following interesting statement: "We have had no trouble since starting chlorination and have not had to clean the reservoir for eighteen months." Thus it appears that the treatment which has stood the test of a part of one summer and an additional entire summer may be considered a preventive rather than a cure.

The author saw the conditions existing at Mexia prior to chlorination and the algae so abundant (protococcus) were apparently copper resistant species.[14] Oscillaria were also abundant.

That chlorination effectively prevents the quantity and quality of growth formerly present in the Mexia reservoir is, to the writer's mind, a remarkable fact; but some credit is due the lime, for without

[14] Chester Cohen. "Chlorination for Algae Control." Jour. A. W. W. A., 17:4:444, April, 1927.

it the efficacy of the chlorine, as reported by Mr. Morgan, was apparently not so great.

Chester Cohen, District Engineer, Texas State Department of Health, reports that in addition to Mexia the following towns in Texas are successfully using chlorine for algae control,—*Graham, Donna, Grand Saline,* and *Laredo.*

At *Richmond, Virginia,* and *Red Bank, New Jersey,* chlorination prevents growth of algae in the aeration and clear water basins.

RETARDATION OR PREVENTION OF SLUDGE PUTREFACTION IN COAGULATION BASINS

Sludge deposits in coagulation basins at plants treating organic waters are subject to anaerobic decomposition. In summer and particularly in southern climates, gas production within the sludge deposits results in rising sludge which is sometimes referred to as "basin turnover." In Panama the basins at the Gatun plant, during the writer's service there, had to be thoroughly cleaned every 14 days and at some seasons even more frequently, or else difficulties from sludge eructations occurred. These disturbances distribute ill-smelling and bad tasting decomposition products through the water.

At *Elizabeth City, N. C., Norfolk, Va.,* pre-chlorination has proven effective in improving the basin condition and in increasing the length of service between washings.

At *Rusk, Cisco,* and *Henderson, Texas,* where coagulation and clarification on the fill and draw plan in multiple tanks is practiced, chlorination of the coagulated influent during filling has proven effective in preventing rising sludge in the quiescent tanks.

Lake Dundee, N. J. (Passaic River water)

A filtration plant at the lake Dundee plant of the National Silk Dyeing Company was constructed in an attempt to purify the waters of the heavily polluted Passaic River which at times in summer resembles a septic tank in appearance. The plant effluent was intended for industrial use only. Trouble was experienced with putrefaction and liquefaction or gas lifting of sludge in the large coagulation basins. Upon the recommendation of Churchill Hungerford, Consulting Engineer, pre-chlorination was adopted to reduce putrefaction and frequency of basin cleaning. Sufficient chlorine is applied to the raw water to insure a slight residual in the basin effluent and from reports available the process is successful.

The author wishes to acknowledge with appreciation the coöperation, and assistance of the various persons who have contributed to this paper.

DISCUSSION

H. E. JORDAN:[15] Indianapolis has two filter plants on the same general site—a slow sand system and a rapid sand system. The slow sand plant is provided with a coagulation-settling basin that under present operating conditions affords about 48 hours retention. The rapid sand plant has a 6 hour coagulation settling basin.

In the summer of 1921, chlorine was first applied to the inflow water to the slow sand plant. The purpose of its use has been—

(a) To reduce the quantity used in post treatment and to increase the margin of safety by producing a filter effluent of better quality before final chlorination than would otherwise be economically possible.

(b) To reduce the use of copper sulphate in settling basin algae control.

Within the last 9 months we decided to pre-chlorinate all water going to both plants. Our procedure before has been to cut it in and out as the quality of the raw water varied.

Pre-chlorination has had an unquestionable effect on algae growth in our slow sand settling basin. We have used copper sulphate to control it each year from 1908 to 1927. During the past summer none was required. Pre-chlorination manifests itself in a variation in the quantity required for post-chlorination as soon as the water travels through the basins and filters. Since our major intent is to reduce the quantity of chlorine required to produce a given excess in the plant effluent we would be missing the mark if it was not clearly demonstrated that such a result obtained. It is thoroughly a matter of habit with us now to vary the inflow dosage directly for the purpose of reducing or increasing the effluent dosage. It may sound queer to speak of intentionally increasing the chlorine demand on the effluent, but we have found that our operators get better mechanical results if the effluent dosage required is not less than 1 pound per million gallons.

The function of double chlorination is to make water so conditioned that an operator has not an iota of doubt of his final effluent quantity if the final excess is maintained. Pre-chlorination unquestionably

[15] Sanitary Engineer, Indianapolis Water Company, Indianapolis, Ind.

lessens the coli density in filtered water. Just to the degree that filtered water coli density is reduced is the danger removed from interruptions to effluent chlorination.

Double chlorination requires close attention to the absorption capacity of the water as indicated by the excess chlorine tests, but since routine operators can be trained to make these tests and do it well, and since no well regulated plant today operates without excess chlorine control, the addition of double chlorination is not a burden.

My experience with pre-chlorination has been that it gives a plant operator a vast amount of relief and assurance as to the quality of his finished product.

CHLORINE ABSORPTION AS A SUBSTITUTE FOR OXYGEN CONSUMED

By Harrison Hale,[1] May Sullivant[1] and Charles B. DeWitt[1]

The work of Wolman and Enslow (1), Froboese (2), Keiser (3), and Meadow and Hale (4) has shown that chlorine absorption is more accurate as an index to the amount of nitrogenous organic matter in potable waters than the standard method for oxygen consumed. Our work has followed lines suggested by their papers and has had for its principal object the development of a satisfactory method for determining the chlorine absorption. As far as possible, the method proposed is similar to the standard test for oxygen consumed, although Meadow and Hale (4) have demonstrated that there is but little correlation between oxygen consumed and chlorine absorbed. The statement of Froboese (2) that $KMnO_4$ attacks carbohydrates, but has little effect on albuminous matter, while chlorine is absorbed more readily by albuminous compounds than by carbohydrates has been confirmed. Since the presence of carbohydrates in a water would indicate less serious pollution than nitrogenous material, it would appear that chlorine absorption is preferable to oxygen consumed, although in a complete examination of a supply, the two tests would supplement each other.

As Meadow and Hale (4) have shown, mass action has a pronounced effect on both chlorine absorbed and oxygen consumed; hence, the concentrations of reagents and the conditions of the test must be constant within rather narrow limits, if comparative results are to be obtained. Meadow and Hale (4) do not propose a definite procedure, and the method used by Froboese (2) and Keiser (3) was not considered suitable for general use because it requires more time than the standard oxygen consumed test and the deterioration of the reagents necessitates a tedious calculation of normality before each day's work.

[1] University of Arkansas, Fayetteville, Ark. Research Paper No. 102, Journal Series.

The most important problems in the early part of our work were to determine whether to introduce the chlorine in chlorine water or in hypochlorite solution; whether to determine the residual chlorine colorimetrically with o-tolidine or by titration with $Na_2S_2O_3$; and the size of the chlorine dosage. Some of our preliminary work showed that NaOCl solution had little advantage over chlorine water in stability, and was less suitable for color comparison with o-tolidine, so its use was discontinued shortly after the data shown in table 1 were obtained. Color comparison with o-tolidine was considered preferable to titration with $Na_2S_2O_3$ because it is quicker and simpler, but it can not be used with large dosages of chlorine. Accordingly, chlorine dosages of different sizes were tried with most of the waters and the residual chlorine was determined colorimetrically for a dosage of 2.5 mgm. or less and by titration for larger

TABLE 1

The effect of heavy dosage on chlorine absorption

SAMPLE	CHLORINE DOSAGE	CHLORINE RESIDUE	CHLORINE ABSORBED	OXYGEN CONSUMED
	mgm.	*mgm.*	*p.p.m.*	
Redistilled HOH	10.53	10.22	3.1	0.0
Redistilled HOH, urea 5 p.p.m.	10.53	9.14	13.9	0.0
Redistilled HOH, urea 5 p.p.m.	21.06	18.44	26.2	
Redistilled HOH, urea 5 p.p.m.	52.60	48.5	41.5	
Redistilled HOH, sucrose 5 p.p.m.	10.53	9.95	5.8	2.12

amounts. Very large chlorine dosage proved undesirable because of the absorption that they allowed with carefully redistilled water. The effect of heavy dosage is shown in table 1.

In making these tests, the chlorine was added in NaOCl solution and a 10 minute absorption period was allowed, at room temperature.

Urea was entirely without effect on the amount of oxygen consumed. This was verified repeatedly. It was found that, even in a concentration of 100 p.p.m., urea was not attacked by $KMnO_4$ as used in the standard test.

Examination of some of the figures given by Meadow and Hale (4), together with some of our own data, showed that in case of natural waters, the oxygen consumed in parts per million was consistently much higher than the chlorine absorbed, although the reverse might be expected in some cases because of the higher equiva-

lent weight of chlorine. A probable explanation of this fact is that, in addition to the selective action of chlorine on albuminous matter and of $KMnO_4$ on carbohydrates, the concentration of chlorine in milligram equivalents was lower than that of available oxygen in the standard test, the time of digestion was shorter, and the temperature lower. The short digestion period was considered desirable, and, as shown above, the dosage of chlorine could not be indefinitely increased with advantage. Increase in temperature of digestion had no appreciable effect on the chlorine absorption of several waters that were known to be free from pollution, but showed a marked increase with some waters that were evidently badly polluted. We next found that chlorine in high concentrations was absorbed by both sucrose and urea, but, in lower concentrations, sucrose was not appreciably affected, although urea was attacked readily. We decided, therefore, to use a chlorine dosage somewhat higher than that employed by Meadow and Hale (4), but much lower than that used by Froboese (2).

On the basis of these observations, we propose the following as a useful addition to the joint A. P. H. A. and A. W. W. A. standard methods of water examination:

Ortho-tolidine method for determining chlorine absorption

Reagents. H_2SO_4 9/N. As prepared for the oxygen consumed test. See A. P. H. A. Standard Methods sixth edition, p. 23.

Ortho-tolidine. As made up for the free chlorine test. See Standard Methods p. 44.

Standards. According to Muer and F. E. Hale. Journal of the American Water Works Association, Vol. 13, pp. 50–69 (1925.)

Dilution water. Heat distilled water to boiling and add strong chlorine water till a 50 cc. portion, after cooling, shows a barely perceptible test for free chlorine with o-tolidine. Dilute with boiling distilled water till a second sample gives no test for free chlorine, and store in a dark bottle.

Chlorine water. Saturate a little distilled water with chlorine. Dilute 20 cc. of this to 1 liter with dilution water, and standardize as follows: to 10 cc. of the diluted chlorine water, add 5 cc. o-tolidine, dilute to 50 cc. In a Nessler tube and mix thoroughly. Allow to stand for five minutes, and compare with the standards. The reading of the standard multiplied by five equals the concentration of free chlorine in parts per million. Adjust the solution to contain 40 p.p.m. of chlorine and store in a dark bottle with a glass stopper.

Procedure. Pipette 100 cc. (note 1) of the sample to be tested, into a 200 or 250 cc. Erlenmeyer flask, and heat rapidly just to boiling. Remove from the fire, and add 50 cc. (note 2) of chlorine water, and set aside for ten minutes. Then, add 1 cc. H_2SO_4 (note 3) and 5 cc. o-tolidine. Transfer to a 200 cc. volumetric flask; rinse the heating flask with dilution water, and add the rins-

ings to the sample. Five minutes after adding the o-tolidine, fill to the mark with dilution water and mix thoroughly. Place 50 cc. in a Nessler tube, and compare with the standards.

Calculations. Subtract the amount of residual chlorine shown by the standards from ten, and multiply the result by two to obtain the chlorine absorption in parts per million.

Note 1. If the sample is so highly contaminated that the residual chlorine is less than 3 p.p.m., repeat the determination using a smaller sample diluted to 100 cc. with dilution water.

Note 2. The chlorine water deteriorates on standing. If it is weaker than 40 p.p.m., a larger quantity is used. The number of cubic centimeters used multiplied by the concentration of chlorine in parts per million should equal 2000. This means an addition of 2 mgm of free chlorine to the 100 cc. water sample.

Note 3. With waters having an alkalinity of less than 200 p.p.m., the acid may be omitted. With waters of high alkalinity, a red and sometimes a green color is produced with o-tolidine that makes comparison with the standards impossible. These undesirable colors do not appear in acid solutions.

TABLE 2

Chlorine absorption by natural waters

SAMPLE	BACTERIA		FERMENTATION TESTS	OXYGEN CONSUMED	CHLORINE ABSORBED	ALKALINITY	CHLORIDE
	0.1	1.0					
				p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*
River	35	100	5/5	1.27	1.6	33.1	1.3
Filter	0	2	4/5	1.08	1.6	37.9	1.3
Clear well	1	2	2/5	1.02	0.5	39.6	2.3
Spring	0	25	None	1.16	1.8	174.4	6.8
Well	32	Num.	4/5	1.37	4.0	243.0	67.0
Well	8	Num.	1/5	7.70	17.0	747.5	221.6
Well	1	Num.	None	3.72	18.0	2060.0	55.5
Well	22	Num.	None	2.12	4.0	449.0	99.5
Well	24	79	1/5	0.88	5.4	135.0	3.75
Well	Num.	Num.	5/5	6.4	4.0	335.0	14.5
Well	?	?	?	5.18	5.0	52.5	13.0

Another method using a chlorine dosage of 4.43 mgm. and determining the residue by titration with N/80 $Na_2S_2O_3$ was worked out and tested, but it was found that the dosage of 2 mgm. was fairly specific for albuminous matter, but had had no appreciable effect on sucrose. For this reason the larger dosage is not recommended.

Some chlorine might be lost also because of the high temperature,

but none was detected in the necks of the digestion flasks with either o-tolidine or potassium iodide starch paper even with a chlorine dosage of 7 mgm.

The proposed method was tested on a number of natural waters, and a few of these results are given in table 2.

TABLE 3

Effect of NaOH on chlorine absorption

UREA	NaOH	CHLORINE ABSORBED
p.p.m.	*p.p.m.*	*p.p.m.*
0	105	0
0	210	0
0	420	0
0	630	0
0	0	0
10	105	4
10	0	4
10	210	4.5
10	315	6.5
10	420	6.0
10	525	7.0

TABLE 4

Effect of Na_2CO_3 on chlorine absorption

UREA	Na_2CO_3	CHLORINE ABSORBED
p.p.m.	*p.p.m.*	*p.p.m.*
0	0	0
0	270	0
0	540	0
10	0	4
10	135	4
10	270	4
10	337	6
10	405	6
10	540	4
10	675	2

In these, and in a number of other waters, it was noticed that there seemed to be some correlation between high alkalinity and high chlorine absorption. Meadow and Hale (4) suggested that this might be due to formation of hypochlorites, but in our work, sufficient acid

was used to decompose any hypochlorites formed, and we are of the opinion that the increased absorption is due to greater activity of the chlorine in alkaline solution. The effect of alkalinity is given in tables 3 and 4. These samples were made up from tap water with additions of urea and alkali as noted.

Urea proved to be but sparingly soluble in strong solutions of Na_2CO_3. This accounts for the decreasing chlorine absorption in the last two samples of table 4.

A sample containing 2000 p.p.m. of fresh urine was prepared on November 29, 1927. This was further diluted, and the oxygen consumption and chlorine absorption were determined at intervals during a period of about six weeks. At first, the oxygen consumed was much higher than the chlorine absorption, but this gradually

TABLE 5

Effect of chlorides on oxygen consumed

CHLORIDE ION	OXYGEN CONSUMED
p.p.m.	*p.p.m.*
0	1.0
100	1.3
200	1.67
400	1.90
500	2.07
1,000	2.48

dropped until on January 6, 1928, a dilution of 20 p.p.m. showed the same oxygen consumption as the distilled water with which it was prepared. Chlorine absorption decreased during this period also, but on the date mentioned, was still 4 p.p.m. greater than for distilled water. Addition of NaOH solution greatly increased the chlorine absorption of this sample.

It has been suggested by Froboese (2) and by Meadow and Hale (4) that high chloride might have some effect on the oxygen consumed test, and some of our results led to the same conclusion. In order to test this, known amounts of chloride ion as NaCl solution were added to distilled water, and the oxygen consumption tested. These results are given in table 5.

Other series gave similar values, but no correction factor could be worked out. It is evident that high chlorides have an appreciable effect on the standard oxygen consumed test, and that they

tend to reduce its significance. During this work, it was also found that standard ammonium oxalate slowly deteriorates if stored in clear bottles. This deterioration was observed in four solutions, but a fifth which was stored in a dark bottle, was unchanged after nine weeks.

CONCLUSIONS

$KMnO_4$ as employed in the standard oxygen consumed test gives no indication of the amount of albuminous matter present in the water.

The standard method for oxygen consumed gives values that are too high if the samples are high in chlorides.

Chlorine in small concentrations has a specific action on albuminous compounds, but in larger concentrations, it attacks carbohydrate material as well.

The method proposed for determining chlorine absorption is rapid in application and furnishes a more accurate index to the amount of nitrogenous matter present than the tests now in use, and it is not appreciably affected by alkalinity below 200 p.p.m.

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THE WATER SUPPLY SITUATION IN KENTUCKY[1]

By E. E. Jacobson[2]

The water supply of Kentucky used for domestic purposes is obtained from springs, wells, lakes and streams. Their quality, quantity and availability are the determining factors in their selection. At present there are only a few cities or towns in Kentucky which have a population of 1,000 or more which do not have a water system. The plants differ widely in size and type and include devices of almost every description.

DESCRIPTION OF SOURCES

The surface of Kentucky varies from a flat flood plain along main rivers and their principal tributaries in western Kentucky through a gently rolling section, known as the "Blue Grass," to the mountainous region of eastern Kentucky. The types of surface described have in their respective areas an influence on the local problem relating to water supply resources.

STREAMS (OR SURFACE WATER)

Streams or surface water used for domestic supplies have in many cases their source in the mountains. These mountain streams come from springs and drainage from coal mines. At one time they were comparatively safe, but with the increase in population in the coal mine region of the Kentucky mountains, the increase of sewage, for the most part disposed of in these streams, have so polluted them that treatment is absolutely necessary. The water plant at Frankfort, is a typical small plant having for its source of supply the Kentucky River. The purification stages in this plant are coagulation, sedimentation, filtration and sterilization.

[1] Presented before the Kentucky-Tennessee Section meeting, January 21, 1927.

[2] Assistant Engineer, State Board of Health, Louisville, Ky.

IMPOUNDED

At many places where small streams are used to supply comparatively large towns, the demand during periods of low water exceeds the supply and storage reservoirs have been constructed to insure against a possible shortage of water. The suggestion is often advanced that the water company should own the entire drainage area of an impounded supply and that the pollution of the supply could thereby be avoided. One must consider, however, the large amount of capital that would give little, if any, returns.

When the water shed is small it is possible to employ a watchman to patrol the area to prevent unnecessary pollution on the water shed. Even then, the solution of the problem resolves itself into an educational process rather than legislation. The American people, especially, are apt to break restrictions of this nature when the possibility of being detected is small.

However, prolonged storage alone must not be relied upon for a safe water. In every case a disinfecting agent must be added to the water before reaching the consumer and in most cases coagulation and filtration will be needed in addition.

Lexington secures its raw water from three lakes. A conscientious effort is made in supervision of the drainage area or water shed to protect these lakes from pollution. The raw water is treated in the Lexington plant by coagulation, sedimentation, filtration and sterilization.

WELLS

The geological formation of Kentucky varies from hard non-porous sandstone to soft cavernous limestone and in the western part of the state loose sand and gravel with no binding material are found.

Many wells located in cavernous limestone regions derive their supply from sink holes. As the limestone rock is readily soluble in water, it gradually becomes dissolved and eroded along the lines of the fissures until large open subterranean channels are formed through which water flows with absolutely no natural purification. In formations of this kind, water may flow for miles underground and show as much pollution at the end as at the beginning of the run. These sink holes are frequently used for dumps where all sorts of refuse, garbage and dead animals are thrown. With every rain the water carries this accumulated filth into the underground channels to pol-

lute every well drawing water from that source. The wells in this type of geological formation must be considered at least as suspicious.

Wilmore is located in that part known geologically as the limestone region. Their water supply is from two deep wells; water being pumped directly from the wells to an elevated tank. Chlorination is relied upon in this plant for the added protection necessary for wells or springs in this region.

In the sandstone or the sand and gravel formation water is as a rule well filtered before reaching the well, the degree of filtration depending on the fineness of the sand through which it passes.

Mayfield desiring a more adequate supply than that afforded by nearby streams, drilled three wells ranging from 200 to 250 feet in depth through strata of intermittent layers of sand and clay. Water is brought to the surface by air pressure into a clear well or storage basin. The water receives no treatment in this plant.

SPRINGS

Wherever the water table intercepts the surface, as along the valleys of the streams, seeps or springs are formed. The quality of this seep or spring water is determined by the region above the water table. The same danger of pollution exists in springs located in a limestone formation as that found in wells of the same character. Disinfection and, in some instances, filtration are imperative in a water derived from springs subjected to such pollution.

Springs are used in Scottsville as a source of supply. Around each spring is a concrete pit covered with a concrete slab from which the water is pumped into a storage basin and then to a stand pipe. The water at this plant is chlorinated.

HOW CLASSIFIED

The public water supplies of Kentucky are classified by the State Board of Health into three classes, according to the quality, quantity, the protection from contamination, and the treatment of the water. The classification of these supplies are "Good," "Doubtful," and "Bad."

A water supply which is rated as good has had sufficient treatment to render that particular supply safe for domestic use. It is of sufficient quantity to supply the needs of that city during all seasons of the year. The clear well, storage reservoir, or other appurtenances

where the treated water is kept, stored or allowed to come in contact with, are properly protected from pollution.

A supply rated as doubtful, either has insufficient treatment, improper operation of treatment plant, or is not protected from pollution, i.e., the clear well may not be properly covered, the storage reservoir faulty in construction or protection, and other features of design or operation which cause the water supply to be of doubtful quality.

A supply which is rated as bad, is unfit for domestic use. The supplies in Kentucky rated as bad are in most cases water pumped from surface streams with no treatment or wells and springs improperly protected from surface drainage.

Some filter plants in Kentucky are rated as bad, due to faulty design and improper operation, consequently producing a water unsafe for domestic use.

The common defects found in Kentucky water supplies are:

Insufficient treatment.
Overloaded filters.
Unsatisfactory operation of plant.
Supply inadequate.
Clear well not covered.
Pipe lines or by-passes leading from river or creeks into clear well.
Unprotected walkway over clear well.
Annular opening between pump column or drop pipe and well casing not sealed satisfactorily.
Impounding reservoir not adequately protected from pollution.

The classification of public water supplies in Kentucky for 1927 is shown in table 1.

NEW PLANTS AND IMPROVEMENTS

Plans for water supply improvements for the year 1926 called for an expenditure of nearly $600,000. The majority of these improvements are now nearing completion.

The estimated cost for water improvements for 1927 was nearly $400,000.

Water works at Franklin and Mt. Vernon have been recently completed. Louisville, Georgetown, Princeton, Harlan, Cynthiana, and Augusta have either new plants or improvements now under construction.

TABLE 1

Classification of public water supplies in Kentucky

PLANTS	TYPE	TREATMENT	RATING
9	Surface water	None	9 bad
11	Surface water	Disinfection	5 good 4 doubtful 2 bad
9	Surface water	Coagulation and disinfection	8 doubtful 1 bad
33	Surface water	Filtration and disinfection	27 good 5 doubtful 1 bad
36	Well water	None	10 good 19 doubtful 7 bad
2	Well water	Disinfection	1 good 1 doubtful
6	Spring water	None	3 doubtful 3 bad
4	Spring water	Disinfection	1 good 3 doubtful
9	Spring or well with softening		8 good 1 good
1	Distilled water		1 good
3	Not completed		

Good	53
Doubtful	44
Bad	23
Not rated	3
Total plants	123
Railroad supplies inspected	23
Total all supplies	146

LABORATORIES

No paper on the water supplies of Kentucky would be complete without some mention of the increasing number of laboratories in water works now being used in the control of purification processes.

There are 10 filtration plants in Kentucky which have equipment and facilities for making analyses.

Tests are made at these plants on water in order to ascertain those qualities of the raw water which affect its treatment, to measure the improvement effected by purification, and to make sure that the water that goes to the consumer is up to the standard of purity.

Where at all practicable, it is certainly advisable to have laboratory control for the plant, whereby the operator is able to check each step in the purification process. In this manner he is able to control the operation so that each unit will do its duty with a minimum amount of chemicals. Not only is a laboratory essential in the proper operation of a filter or softening plant, but it is also an economical factor in water purification.

CONCLUSION

The superintendent of a water works may be compared to the conductor in charge of passenger trains. In the proper handling of the engine and cars rest the lives of the people on the train. The conductor must have proper coördination between various men whose duty it is to run the train as brakeman, engineer and fireman. The train and engine must not be faulty in design or construction, the rails must be in good condition and the engineer experienced in the handling. Likewise in the hands of the water works superintendent rest the lives and health of the people in that city or town. Similarly he must have coöperation from other officials. His plant must not be faulty in design or construction, the distribution system must be in good condition and the operator experienced in the proper handling of the various units in his plant.

WATER SUPPLY PURIFICATION IN TENNESSEE[1]

By Howard R. Fullerton[2]

Sanitary engineering activities in water purification on a statewide basis were first undertaken in Tennessee in 1919 when the United States Public Health Service detailed a sanitary engineer to the State Board of Health. Later the Legislature established a Division of Sanitary Engineering, beginning July 1, 1921. Municipal water supply improvement was one of the first things undertaken and has been strongly pursued ever since.

At first a water works survey by circular letter was made of cities and towns in the state. The information obtained, although quite complete in some instances, was largely meager. The letter survey was followed by a personal survey and inspection of all of the water supplies. The surveys disclosed the fact that few of the public water supplies were clear, unpolluted, and safe during the entire year, and that many supplies were grossly polluted over long periods of time.

Perhaps no other state has such a variety of sources of water or as many different types of treatment plants. It will, therefore, be of value in reviewing the progress of water supply purification in Tennessee to review for a moment the above mentioned condition.

All of the water supplies in the western third of the state, lying between the Tennessee and Mississipi Rivers, are obtained from deep wells, varying in depth from about 350 to 1400 feet. The strata penetrated are clay and sand. Much of the water is impregnated to a more or less degree with sulphur and iron.

Central Tennessee is largely a plateau area, traversed by the Cumberland River and a few small tributaries, and by tributaries of the Tennessee River. This section is almost entirely underlaid with limestone formation, with bed rocks protruding at the surface or at best only a few feet below the surface of the ground. In limestone

[1] Presented before the Kentucky-Tennessee Section meeting, January 20, 1927.

[2] Director, Division of Sanitary Engineering, State Department of Health, Nashville, Tenn.

areas waters will often flow underground for miles without receiving any natural filtration, which tremendously increases the problem not only of securing a supply without excessive cost but creates the additional problems of maintaining the supplies safe for general domestic use after they are obtained. Water supplies in this area are secured from springs, wells and streams.

The eastern section of the state is mostly mountainous and water supplies are secured from springs and streams.

Actual progress of water purification can perhaps best be discussed under its several phases.

IRON REMOVAL

In 1921 there were 2 iron removal plants in cities of populations of six thousand and five thousand respectively. Both used aeration accompanied by chemical precipitation, but only one employed filtration. Since that time 2 additional cities have put in aeration and sedimentation and 3 others have put in aeration and filtration, either with or without chemical precipitation. The City of Memphis is included in the latter group. For the past seven years iron removal from public water supplies in Tennessee has increased from 2 to 7 cities, from 1,000,000 to 17,500,000 gallons per day at the present time.

DISINFECTION

Liquid chlorine is now almost universally used as the medium for disinfection of water supplies in Tennessee. In 1917 only 1,000,000 gallons of water were disinfected in this manner. In 1920 the quantity had increased to 6,000,000; in 1922 to 15,000,000; in 1924 to 40,000,000; and to December 31, 1927 to 54,000,000.

At the present time there are four small water plants using hypochlorite and one using ultra violet ray.

FILTRATION

From the preceding description it is readily seen that water purification by filtration is a very important and much used method of water treatment in this state.

In 1919 only 30,000,000 gallons of water in the state were filtered. When the Division of Sanitary Engineering was established on July 1, 1921, 38,000,000 gallons were so purified. Since that time filter plants of 74,000,000 gallons capacity have been built, making an

increase of 66.1 per cent in new filter plant capacity built in the last six and one-half years. This does not include a 28,000,000 gallon filter plant to be constructed at Nashville, a contract for which has already been let.

Exclusive of the Nashville plant, which will serve some 160,000 people, the population protected by new filtration plants has increased from 208,592 on July 1, 1921, when the Division of Sanitary Engineering was established, to 318,000 on December 31, 1927, an increase of 53 per cent. When the Nashville plant is completed the increase will be 129 per cent.

TABLE 1

Distribution of public water supplies by population groups, Tennessee

POPULATION GROUPS	POPULATION OF TOWNS IN GROUP HAVING PUBLIC WATER SUPPLIES	PER CENT OF TOTAL POPULATION IN GROUP LIVING IN TOWNS HAVING PUBLIC WATER SUPPLIES	NUMBER OF TOWNS HAVING PUBLIC WATER SUPPLIES
20,000 and up	493,207	100	5
20,000–10,000	14,806	100	1
10,000–6,000	54,619	100	7
6,000–4,000	67,235	100	14
4,000–3,000	42,915	100	13
3,000–2,000	46,719	100	18
2,000–1,500	20,623	92.6	12
1,500–1,000	27,836	86.8	23
1,000–750	8,430	50.6	10
750–500	12,509	51.2	21
500–400	4,807	43.2	11

Total population of state, 2,430,144.

32.7 per cent of total population in state live in towns having public water supplies.

There are 42 railroad water supplies in the state. Very few of these supplies were certified as safe for drinking in 1921, while in 1927 all have been inspected and those of poor quality eliminated. Water can now be drunk on any train where water is secured in this state with reasonable assurance that the water is safe.

It is believed that the percentage increase in new filter plant construction, in population protected by new filter plants, and in water disinfected with liquid chlorine in the last five and one-half years in Tennessee are records unexcelled by any other state.

In table 1 the distribution of public water supplies in Tennessee by population groups is shown.

ACTIVITIES OF THE BOILER FEED WATER STUDIES COMMITTEE DURING 1927–28[1]

By S. T. Powell[2]

Scientific knowledge in matters relating to sanitary engineering has been greatly enriched by the coöperative efforts of members of this Association through intelligent investigations, particularly in reference to matters relating to water purification and allied public health measures. It has been the desire of the Boiler Feed Water Studies Committee to accomplish similar results in this industrial field. The general interest manifested in the activities of the Committee's work is indicative of its importance and confirms the wisdom of undertaking the program which we believe comes within the legitimate scope and function of this Association.

From a purely restricted Association activity it has grown until at the present time the movement is sponsored by six of the major engineering organizations, with membership in many countries throughout the world. The widespread interest in the work of this Committee has been shown by the large number of requests for papers and reports relating to the Committee's activity. Requests for these have been received during the past year from engineers and chemists from five European countries and from Australia and Japan. The progress reports issued annually for the past two years have been circulated widely in this country and Canada.

Steam generating conditions in power plants and on steam railroads have undergone such radical changes in recent years that the necessity for satisfactory water for these purposes has placed boiler feed water among the important engineering materials. The purification of feed water and the control and operation of equipment necessary therefor are important engineering problems which can no longer be ignored.

[1] Presented before the Boiler Feed Water Session, San Francisco Convention, June 12, 1928.

[2] Chairman, Boiler Feed Water Studies, American Water Works Association; Consulting Chemical Engineer, Baltimore, Md.

The most important factor in these studies has been the accumulation and coördination of available data, accomplished through the Technical Committees' activities. The results of this work have appeared in the several progress reports published in the journals or proceedings of the sponsor societies. Although these collaborations have proven interesting and instructive and are essential in an investigation of this kind, they are, however, merely the foundations for further work. These data have demonstrated clearly the need for research. Many of the problems may only be solved by this procedure. The solutions to corrosion, priming and foaming, embrittlement and numerous other operating difficulties require a better understanding of fundamentals.

The scope of the research studies proposed has been given much thought by the Executive Committee. The following is a brief outline of the more important items requiring attention:

1. A physico-chemical study of the properties of solutions in order to learn the primary causes of foaming and priming.
2. Experimentation on a plant scale to establish the effect of various organic and inorganic substances on priming and foaming. This work is to be done in coöperation with central station operators and locomotives.
3. Study of boiler compounds for (*a*) antiscale, (*b*) antifoaming, (*c*) anticorrosion.
4. Study of zeolite treatment in respect to priming, foaming, corrosion and scale inhibition.
5. The value of evaporators in conjunction with other methods of feed water treatment.
6. Study of the causes of and methods for inhibiting corrosion in condenser tubes.
7. The elimination of deposits from condenser tubes with special reference to their chemical removal.
8. The value of electrolytic methods for the inhibition of corrosion and scale formation.
9. A study of the use of chemicals for deaeration of feed water.
10. Studies to increase the efficiencies of evaporators and appurtenant equipment.
11. Determination of the corrosion rate and hydrogen gas evolution *in the absence* of dissolved oxygen through the range of acidity and alkalinity in general practice and a temperature range from 140 to 450°F. on the heat transfer surfaces of the water cycle in steam plants. In this problem the determinations should be made on distilled water and on water containing varied amounts of impurities.
12. Repetition of No. 11 with dissolved oxygen present in amounts within the ranges usually found in practice. Investigation and develop-

ment of field method for determining very small amounts of oxygen in solution.

13. Determine in the field dissolved oxygen in locomotive and stationary boilers at various points in the circulating system. Include boilers of various types. The field tests on boilers should include some of the same type operating at various pressures.
14. Study the variations in hydrogen-ion concentration, and alkalinity or acidity at boiler temperatures compared with these variables in the same water at normal temperature (68°F.). Investigate the influence of high concentration of common salts on these variables at high temperatures.
15. Study in laboratory and field the formation of protective films deposited from water on heating surfaces. The relation between dissolved oxygen, alkalinity, chlorides and protective scale formation should be investigated.
16. Study pitting found under boiler scale, particularly in locomotives operating in certain geographical sections.
17. Electrolytic prevention—cause and effect.
18. Corrosion in boilers originating from organic materials.
19. Study action of inhibitors (organic and inorganic), at boiler temperatures.
20. Further studies on the effect of caustic solutions as an accelerator of embrittlement, especially at high temperatures and pressures.
21. The inhibiting or retarding effect of structure of metals on embrittlement.
22. The effect of phosphates, chlorides and other constituents in water in inhibiting or accelerating embrittlement.
23. The possibility of producng embrittlement under certain load conditions and with improperly treated boiler metal in the presence of water low in alkaline salts.
24. The effect of dissolved oxygen in accelerating the embrittlement of boiler steel.
25. The elimination of the embrittlement of boiler steel by the use of forged drums in the presence of high caustic concentrations in the boiler waters.
26. The relation, if any, between corrosion and embrittlement.
27. Investigation of organic salts as an inhibitor of embrittlement.

The activity of the Executive Committee during the year has been confined largely to ways and means for securing the funds necessary for furthering the establishment of research fellowships to study some of the problems indicated herein. The Finance Committee appointed by the Executive Committee has prepared a comprehensive statement relative to the financial requirements for the proposed work. It has been estimated tentatively that $60,000 annually for

a five year period will be required to carry this research work forward. The specific amounts allocated for the studies are as follows:

Technical Committee No. 3—Priming, foaming and allied problems	$10,000
Technical Committee No. 4—Surface condensers, evaporators and deaerators	10,000
Technical Committee No. 5—Corrosion of boilers and appurtenances. Electrolytic scale prevention	20,000
Technical Committee No. 6—Embrittlement of boiler steel	20,000
Total	$60,000

A number of companies and associations affiliated or interested in this work have responded to the Committee's requests and there is now available on deposit with the Treasurer of the American Society of Mechanical Engineers about $3,000 with a further commitment of an additional $20,000 per year. The availability of this latter sum is contingent on the support of other interested groups to complete the entire specified annual fund of $60,000. One of the larger affiliated associations now has under advisement an appropriation of $20,000 a year annually towards this work.

Active work on the research program will not be undertaken until the entire sum is available or commitments are received from responsible groups assuring support for the proposed studies. Wisdom of this decision must be apparent to all who realize the scope of the investigations. It is desired that the financial program as outlined may be completed during the next few months so that active work may be undertaken this year.

Reports from all Technical Committees will be available for publication again this year as in the past. These reports will be published in the Journals of this and other Associations affiliated in this cooperative study.

Bibliographies have been compiled during the year relating to feed water problems. This work has been made possible through the Editorial Staff of the American Society of Mechanical Engineers working in coöperation with the abstract editors of this Association and other interested groups. These short abstracts have been of great value to many engineers, since it has made possible the correlation of published material on this subject gathered from many Journals throughout the world.

Possibly the most constructive work in the Committee's activities

this year is the proposed preparation of Standard Methods of Water Analyses for industrial work and principally for Boiler Feed Water uses. The existing Standard Methods of Water and Sewage Analyses has been taken as the basis of the Committee's work. Where these methods are satisfactory and adaptable to feed water uses they will be taken as the Standard Methods for this work. Changes and additions to some of the present procedures are necessary, however, for special uses in power plants.

It is not the intention of the Committee to attempt to change Standard Methods of Water Analyses for sanitary uses, but merely to modify the existing procedures to meet the industrial requirements. Eventually, Standard Methods might be embodied in the present publications or as a separate volume applicable particularly to the specific needs in the industry. This may only be done by joint agreement with all interested groups after the tentative standards have been demonstrated to be satisfactory.

The Committee has prepared a tentative method for the determination of dissolved oxygen which has been sent to a large group of industrial chemists for their criticism. This method is a modification of the Standard Method, but applicable to power plant requirements. Other determinations are to be studied by the Committee at a later date.

The Chairman desires to express his appreciation to the Executive Committee and to all those who have supported this work during the past year.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Unifying San Francisco's Big System. M. M. O'SHAUGHNESSY. Water Works Eng., **81**: 12, 773, June 6, 1928. Provision has been made (1) for completion of the Hetch Hetchy aqueduct which involves construction of the remaining links from the Sierra Nevada to point of connection with local system; (2) for purchase of Spring Valley Water Co. Completion of Hetch Hetchy aqueduct involves work on 16 miles of tunnels already under construction, and on 28.6 miles of tunnels and 49.7 miles of pipe lines not yet commenced. System is planned for delivery of 400 m.g.d. to San Francisco and environs. It is planned to utilize the fall of the water as it flows from its source high in the Sierra Nevada region down to San Francisco for generation of hydro-electric power. Tunnels are built for full flow of 400 m.g.d. and reservoirs proportioned for a dependable yield of 200 m.g.d. The aqueduct tunnel of 400 m.g.d. capacity is now nearly all excavated through 15.8 miles of Foothill country between the power plant and San Joaquin Valley, but has still to be lined with concrete. Still to be constructed are the San Joaquin Pipe Line and the Coast Range Tunnels. Pipe line across the former to be 47.4 miles long, 60 inches in diameter, with 60 m.g.d. capacity. For 30 miles this pipe line will be under a head of 500 feet. Main aqueduct in Coast Range division of 25.12 miles of tunnel sets world's record for length of continuous tunnel between portals. It has been divided into six sections by sinking of five shafts along the line. Work is being done by city forces under direct supervision of City Engineer. Shafts are built with three compartments, two for hoisting and one for pipes and manway. Clay found in Indian Creek Shaft having shown tendency to swell, reinforced gunite concrete installed as closely as possible behind work of excavation proved satisfactory remedy. Each shaft is to be carried 50 feet below tunnel grade and a rock pocket will be excavated alongside to receive tunnel muck.—*Carl Speer, Jr.*

Cutting a 5-Mile Tunnel Through Marl. JAMES E. GIBSON. Water Works Eng., **81**: 12, 775, June 6, 1928. There is difficulty in obtaining a satisfactory

[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

water supply for Charleston, S. C., due to sea water pollution even a great distance inland owing to tidal influences. In 1823 and in 1856 attempts made to secure water from a well, but results were unsatisfactory. Finally in 1878 another attempt resulted in a well 1970 feet deep yielding 465 gallons per minute under 22 pounds pressure. Up to this time population had depended upon water supply from cisterns or shallow wells. As supplies from artesian wells never proved adequate, an independent surface supply was sought for.

Upon recommendation a dam constructed for Goose Creek, with supply estimated at five and one-half million gallons per twenty-four hours, proved satisfactory at first, but later became inadequate. In 1916 the dam carried out with loss of practically the entire volume of storage water. Government demands for additional supply for Embarkation Depot led to erection of temporary pumping station at Bacon's Bridge on Ashley River. In 1927 further studies were made for additional water supply. Results showed Edisto River at Givhans Ferry to be best available supply. This lies to west of Goose Creek pumping station with Ashley River intervening. Drainage area of Edisto River comprises 2476 square miles; elevation of water 26 feet above mean sea level. A conduit built from Edisto River and Hanahan storage reservoir would carry water by gravity into Goose Creek storage basin. Funds now available are not sufficient to complete this development. A proposition in line with future schemes is to divert water from Edisto River into Ashley River by means of a four and one-half mile tunnel of seven-foot horseshore shaped section, with inlet portal shaft and intake works near Givhans Ferry and exit portal into open canal near Bobs Lake on Ashley River. Construction would be through marl, eroded by actions of currents in streams, and at about mean sea level. Physical qualities vary from soft fine material with softness of plastic clay to hardness of high grade limestone. Shafts would be concrete lined.—*Carl Speer, Jr.*

Iodine in the Public Water Supplies of Massachusetts. H. W. CLARK. Jour. New Eng. Wat. Works Assoc., 42: 2, 132, June, 1928. In Massachusetts there are 219 cities and towns with public water supplies, about equally divided numerically between ground and surface waters, and available to 96 per cent of population of the state. The surface waters, however, have considerably greater volume and importance, being used by about 85 per cent of the population. In 1925 and 1926 study was made of iodine content in 97 supplies including 62 surface, and 35 ground waters, as also in samples of river water, rain water, and of fish. Results showed: (1) waters of the state differ greatly in iodine content; (2) certain supplies vary in content at different seasons of the year, less iodine being present in winter and spring. Great differences in iodine content between different supplies are due to the great variation in character of soils and rocks of the state. The surface of Massachusetts is very uneven with hills and valleys succeeding each other rapidly; its soil, sand, and rocks were left or deposited by the glacial drift. The soils and sands of the Tertiary formation covered by the glacial drift are rich in iodine, while the amount of iodine found in rain water was negligible. Method used to determine iodine varied but slightly from that given by MCCLENDON in Journal Biological Chemistry 60: 2, June, 1924. Thirty gallons of water

were evaporated to dryness and residue ignited. Na_2CO_3 was used to keep water alkaline to phenol-red paper during evaporation. It was not found possible to dissolve ignited residue in 15 cc. of water, as recommended by McClendon, but volume was usually about 25 cc. For waters low in iodine the entire sample is necessary for proper readings. With larger volume of solution to extract, larger volume of carbon tetrachloride was used than by McClendon. Otherwise his procedure was followed. Table of results is given.—*Carl Speer, Jr.*

Eliminating Turbidity and Trade Wastes. G. E. Rickard. Water Works Eng., 81: 11, 671, May 23, 1928. Wheeling, W. Va., plant put in operation on February 23, 1925, was built for an average consumption of 20 million gallons. Detention period of grit chamber is one hour; of mixing chamber, thirty minutes; and of settling basins, four hours. There are ten two-million-gallon filter units. A clear well, steel wash water tank, concrete bins for chemical storage, and dry feed machines make up rest of plant. The turbidity of the raw water has ranged from 20 to 2000 p.p.m. Low turbidity occurs during June, July, August, and September when the river is fed from underground sources and is highly polluted with industrial wastes. The carbon dioxide content of the raw water has varried from 3 to 40 p.p.m. High content is due mostly to trade wastes. The alkalinity of the raw water has a range of 12 to 32 p.p.m. and the iron has varied from 0.1 to 7.2 p.p.m. In order that the application of alum may be kept at a minimum, qualitative tests for ferrous iron are made. The iron content of the filtered water has been reduced to a trace or zero. Chlorides are responsible for some of the increase in hardness during summer months. Medicinal tastes, due to phenol uniting with chlorine, were very noticeable in winter months of 1925–1926. Dosage of chlorine was reduced to 1.1 pounds per million gallons. The filtered water has conformed to the Treasury Department standard except for about fifteen days on which from two to three of the five 10 cc. tubes showed gas. The following conclusions are given based on the experiences at Wheeling: (1) The application of large quantities of chemicals in treating water causes a great amount of unnecessary trouble when a lesser amount would do more good and improve operating conditions. Alum dosage was cut from 0.94 grains per gallon in 1925 to 0.32 in 1927. Filter runs were increased from 31.8 hours in 1925 to 51.9 hours in 1927. (2) A small amount of ferrous iron in a highly turbid water cuts the amount of alum necessary by 50 to 60 per cent. (3) A more satisfactory way of adjusting chemicals is by paying attention to the distance that the "floc" travels in the settling basins and to the amount of "floc" left in the applied water. (4) Bacterial counts and the B. coli index are lower in Wheeling than in other Ohio River cities due to the Warwood dam being only about ¾ mile below the plant. This, in normal pool stage, tends to form a primary settling basin aided by the presence of ferrous salts. (5) A saving of $1.07 per million gallons was accomplished in 1927 over 1925.—*Carl Speer, Jr.*

Saving and Keeping Elevated Water Storage Tanks or Towers and Standpipes in Sanitary Condition. D. W. Pyle. Proc. Ninth Texas Water Works Short School, 219, January, 1927. Many tanks are lost through laxity in the proper

care of the surfaces in due time. The surfaces should be cleaned by an electric wire brush and the paint supplied by a compressed air spray. The installation of a cleanout valve has the following advantages: (1) sediment can be flushed out without emptying tank or removing from service; (2) many tanks have the riser main extending up into the tank some distance, making it impossible to flush by draining without a cleanout valve; (3) cleaning by means of a flush valve prevents the contamination due to other methods. The bottom of standpipes should be fitted with a 3 or 4 inch valve and covered with a coat of rock asphalt or tar higher on the opposite side. This permits efficient flushing by the pressure of the water alone.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abstracts*).

Failure of Slow Sand Filtration in Madras City. J. W. MADELEY. Surveyor, 72: 1873, 593, December 16, 1927. Description of the water works of Madras, India, and of the difficulties experienced in the operation of the slow sand filters, together with an outline of suggested improvements. The source of supply is Red Hills Lake, situated 7 miles from the filter plant. The numerous villages situated on the watershed have no drainage systems, and during the rainy seasons their filth is washed directly into the lake without treatment. The water, consequently, is of poor quality. The water works were constructed to supply 25 gallons of water per capita per day, to a population of 660,000 and consist of an intake tower, a 7-mile underground conduit of concrete and brickwork, 17 open slow sand filters with total area of 8¼ acres, 4 underground filtered water tanks with total capacity of 6.5 m.g., a 1.5-m.g. elevated steel balancing tank, and a cast-iron pipe distribution system throughout the city. Most of these works were put in commission about 1914–1915. During the hot weather hydrogen sulfide is produced in the filters. When filters are stopped a black layer about 2 inches thick is found at the bottom of the fine sand, immediately above the coarse sand, and occasionally a similar layer immediately below the surface of the fine sand. This is probably iron sulfide as the sand contains iron. Liberation of the hydrogen sulfide through the sand of the filter causes formation of crater-like holes in the sand surface, which, of course, interfere with the efficiency. The presence of the hydrogen sulfide in the filtered water prevents satisfactory chlorination. After studying the situation, the author recommended that the slow sand filters be converted into rapid sand filters by emptying and using filters Nos. 1–14 as preliminary settling basins, Nos. 15 and 17 as coagulation basins for alum treatment, and dividing Nos. 16 into 14 rapid sand filters to be operated at a rate of 100 vertical inches per hour. This would give a net capacity of 20 m.g.d., to supply a consumption of 17 m.g.d.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abstracts*).

Value of Preliminary Sedimentation in Water Purification. FRANK BACHMANN. Proc. Ninth Texas Water Works Short School, 173, January, 1927. An article that should be of particular interest to those operators of water purification plants whose water is taken from rivers of the Mississippi drainage basin where wide fluctuations of turbidity is experienced. The advantages of preliminary sedimentation in the treatment of turbid waters are as follows:

1. The removal of the bulk of the turbidity thereby reducing the load on the coagulation basins and consequently the cost of cleaning these basins. 2. Pre-settling (*a*) gives a water low in turbidity which results in smoother plant operation; (*b*) reduces materially the cost of chemicals for coagulation and softening; (*c*) reduces cost of water wasted with sludge as this water has not been treated with chemicals. An interesting discussion of the above advantages is given with several charts and tables to illustrate the points brought to light.—*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abstracts*).

Water Pollution Control. Cannery Wastes. HOMER S. MURPHY. J. M. HEPLER and E. F. ELDRIDGE. A Compilation covering Activities, Experimental Work and Coöperation Investigations as Conducted by the Department of Conservation, Department of Health and the Michigan Canners Association. The first section of this pamphlet mentions the history of experimental work on canning factory waste. Next follows a condensed report of the operation of the Michigan Canners Association experimental waste treatment plant located at the W. R. Roach & Company's plant at Kent City. Members of the association voted to assess themselves a sum of 0.2 of a cent per can based on the 1925 pack for the purpose of studying the problem. The plant consisted of fine screens; settling tanks, one of which could be used for digestion; and filter beds of different types. Sprinkling filters gave quite satisfactory results. The intermittent sand filters, however, showed a tendency to form a hard crust. Cinder filters will be abandoned. The small amount of sludge obtained indicates the possibility of supplanting the tanks with fine screens. —*A. W. Blohm* (*Courtesy U. S. Public Health Eng. Abstracts*).

Upward Pressures under Dams: Experiments by the United States Bureau of Reclamation. JULIAN HINDS. *Discussion.* Proc. Am. Soc. Civ. Eng., **54:** 4, 1349–57, April, 1928. E. L. CHANDLER. Description is given of the measurements of upward pressure under the Pinhook Dam at Maquoketa, Iowa. The measurements offer excellent evidence in support of the "line-of-creep" theory under considerable variation of head. It is not wise to assume pressures less than those that apply under the "line-of-creep" theory, although that theory probably errs somewhat on the side of safety.—*John R. Baylis.*

Hydraulic Studies and Operating Results on the Miami Flood Control System. C. H. EIFFERT. Proc. Am. Soc. Civ. Eng., **54:** 5, 1371–89, May, 1928. The assumptions on which the designs of dams, conduits, and channels were based, have been confirmed. The outlet structures have fully met the requirements for dissipating the energy of the water as it leaves the conduits. Valuable information is being secured from the rainfall and run-off records.—*John R. Baylis.*

The Treatment of the Water Supply of the City of Columbus, Ohio. C. P. HOOVER. *Discussion.* Proc. Am. Soc. Civ. Eng., **54:** 4, 1329–37, April, 1928. F. H. WARING. The importance of the research at Columbus on water-softening is stressed. Carbon dioxide was first used at Defiance, Ohio, and its use in water softening plants has spread rapidly until it is now regarded as

a necessity. With the use of carbon dioxide water can be treated with an excess of lime and then recarbonated. The excess lime treatment is very effective in sterilizing the water, and has made it possible to avoid the use of chlorine in several Ohio cities having badly polluted waters. G. W. FULLER. The Columbus water softening plant was a pioneer plant in municipal water softening. The tests that led to its basic design were made in a somewhat haphazard way so far as anything outside the laboratory was concerned. It was not the ambition of the designers to produce a completely softened water, but to make it approach in hardness that of the Great Lakes. When the plant went into service a hardness of 120 p.p.m. did not satisfy the citizens. They wanted a softer water. Some of the things that must be considered in the production of water suitable for domestic and industrial uses are mentioned. R. S. WESTON. The work of Mr. HOOVER is commended. The tendency is towards softer waters. A hardness of 60 to 80 p.p.m. is failing to give satisfaction. The combination of lime-soda and zeolite processes will come into more general use. C. W. FOULK. The Columbus plant removes from 180 to 190 p.p.m. of hardness. This would destroy about $6 worth of soap per year in the average household.—*John R. Baylis.*

Analysis of Arch Dams by the Trial Load Method. C. H. HOWELL and A. C. JAQUITH. *Discussion.* Proc. Am. Soc. Civ. Eng., **54**: 4, 1311–8, April, 1928. B. F. JAKOBSEN. Shrinkage should not be ignored, and it is an error on the side of danger to assume that it does not occur. The division of the load between arches and cantilevers is greatly influenced by shrinkage. It seems better to treat the dam as a pure arch dam and then allow somewhat higher stresses in order to take account of the unknown assistance given by the cantilevers. G. R. RICH. The deflections caused by shearing stresses should not be neglected. An attempt has been made to show that this effect may be readily included in the computation. Foundation deformations probably have an appreciable effect on the division of load between arches and cantilevers.—*John R. Baylis.*

The O'Shaughnessy Dam and Reservoir. J. H. GREGORY, C. B. HOOVER and C. B. CORNELL. *Discussion.* Proc. Am. Soc. Civ. Eng., **54**: 4, 1325–7, April, 1928. J. E. CARMAN. The excavation exposed a section of rock 90 feet thick and offered a good opportunity for a detailed geological study of the formations encountered. B. F. JAKOBSEN. In dam construction it is believed that shrinkage is the most important factor. The leaner the concrete the less will be the shrinkage. Impermeability is of great importance. The writer doubts the advisability of adding a 12-inch layer of a richer mix concrete all around the dam. It will probably crack and produce cracks in the underlying concrete.—*John R. Baylis.*

Precise Weir Measurements. E. W. SCHODER and K. B. TURNER. *Discussion.* Proc. Am. Soc. Civ. Eng., **54**: 5, 1493–1500, May, 1928. R. E. BALLESTER. The formula for discharge over a broad-crested weir with cylindrical up-stream face has been determined. G. S. WILLIAMS. The paper is commended very highly.—*John R. Baylis.*

The Bacterial Destruction of Acetyl Methyl Carbinol. O. B. WILLIAMS and MARIE B. MORROW. J. Bac., 16: 43–8, 1928. Certain strains of the colon-aërogenes group of bacteria are irregular in their behavior to methyl red and Voges-Proskauer tests. Previous work shows that this condition is probably due to certain strains of organisms destroying the acetyl methyl carbinol formed. Using standard media it was found that certain strains do destroy this compound, thereby failing to give a Voges-Proskauer reaction as they should, within the time limit usually used for incubating. This condition is true of pure cultures and is due to the compound serving as a source of carbon for the organism. The use of this test for differentiation of colon groups is questioned.—*Edward S. Hopkins.*

Report of the Arizona State Laboratory for the Year 1927. JANE H. RIDER. Bulletin Arizona State Board of Health No. 44; 8, January, 1928. Arizona is collecting copies of county and municipal maps and indicating thereon the streams that are used as municipal supplies and those that receive polluting substances. Tourists camp inspections and approval have been continued since the inception of this work in 1925.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abstracts).*

The Industrial Waste Research Problem in Southern California. R. F. GOUDEY. Western Construction News, 3: 1, 18, January 10, 1928. Southern California has about 5000 industries many of which have serious difficulties in disposing of liquid wastes. No streams are available for dilution and inland towns will be dependent on high grade treatment with disposal on land or in dry stream beds. Research in industrial wastes is a logical extension of research in sewage disposal. The only practical solution of the problem seems to be to have a research organization as a part either of the Department of Public Health, the Department of Natural Resources, or some other State Department.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abstracts).*

The Conquest of Sewage Contamination. HARRY N. JENKS. Western Construction News, 2: 23, 41, December 10, 1927. This is a well written article for popular reading in which the author discusses the following: The sewage problem; the infection of water resources; from aesthetic sense to common sense; sewage and civilization; sewage disposal; saving our streams from pollution; progress through organization.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abstracts).*

The Twort-D'Herelle Phenomenon. R. BRUYNOGHE. Journal of State Medicine, 35: 11, 621, November, 1927. The author discusses the subject under the following headings: historical; means of detecting bacteriophage; the resistance of germs toward bacteriophage influence; the properties of bacteriophages; plurality of bacteriophages; reciprocal resistance, neutralization of bacteriophages; properties of the bacteriophages; the bacteriophage complexity. The literature related to each type is reviewed briefly. The article is to be continued in subsequent numbers of the Journal.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abstracts).*

Sources of Underground Water Supplies: The Need for Investigation. S. R. RAFFETY. Surveyor, 72: 1873, 601, December 16, 1927. A discussion of the factors which affect the yield of underground sources of supply, in which the necessity of collecting and classifying observations on such supplies, as has been carried out in the case of surface supplies, is emphasized.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abstracts).*

McQueen *vs.* Owen Sound and Others. Anon. Canadian Engineer. 54: 1, 111, January 3, 1928, and 54: 2, 124, January 10, 1928. In the case of McQueen *vs.* the City of Owen Sound in 1926 the trial judge found "that the plaintiff's illness (typhoid) was caused by the negligent supply to her by the defendants of contaminated water and awarded her damages" ($2000). The defendants appealed and the conclusions of the Appeal Court are summed up as follows: "First, that there is no direct evidence that the water supplied the plaintiff by the defendants carried typhoid bacilli and that there is no indirect evidence to warrant the inference that it did: Therefore it could not have caused her illness. On this ground alone her action fails. Secondly, I am of the opinion that even if the water did contain typhoid bacilli the evidence does not warrant the inference that of all possible causes of the plaintiff's illness the most probable one was contaminated water. For this reason, also, her action fails and the judgment sould be set aside and the action dismissed with costs below and of the appeal." It is believed by the Appeal Court that not sufficient importance was attached to the possibility of contamination carried by flies from neighboring septic tanks, the overflow from which flowed in an open ditch in the vicinity of the plaintiff's residence.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abstracts).*

Latest Developments in Water Purification. GEORGE W. FULLER. Proc. of Ninth Texas Water Works Short School, January, 1927, 182. A brief discussion of each of the developments is given with reference to the towns in which they were tried: (1) Superchlorination and dechlorination; (2) split chlorination and prechlorination; (3) double coagulation; (4) double filtration (5) water softening; (6) effluent aeration; (7) mechanically cleaned settling basin; (8) new methods in coagulation of water; (9) boiler feed water; (10) new purification plants; (11) experimental studies on filter loading.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abstracts).*

The Development of the Hydraulic Jump Mixing Flume for Water Purification. J. W. ELLMS Proc. Ninth Texas Water Works Short School, January 1927, 180. The development of water purification processes pointed out the fact that thorough mixing of the chemicals with the water was a necessary procedure. The old baffled mixing chambers and mechanical agitators were found to be faulty in many respects. The need for the proper mixing device was seen. Experimental work was carried on at Cleveland, Ohio, by the city water department under the direction of the author who suggested the use of this phenomenon. Results of this work led to the following conclusions: (1) It is possible to design a flume in which the phenomenon can be produced; (2) costs of building the flume are about one third that of the baffled mixing

chamber; (3) the flume can be placed at the most suitable place; (4) the loss of head is low; (5) it is an extremely efficient mixing device. The many installations now being used are ample evidence of the effectiveness of this method of mixing.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abstracts).*

Work for the Water and Sewage Purification Committee. H. H. KING. Report of the King Institute of Preventive Medicine, Guindy, for the year ending March 31, 1927, 10. This is a progress report of a portion of the work carried on by the committee on sewage and water purification. Work in regard to the value of percolating non-submerged filters as compared with an ordinary submerged slow sand filter as well as a comparison of open and closed septic tanks and Imhoff tanks was carried on. At the same filtering rate for water the percolating filter gave the best results. At increased head over that used in the submerged filter the same results were obtained except for oxygen absorbed which was nearly equal. At increased rates for both filters about the same ratio of efficiency was maintained from both a chemical and bacteriological standpoint.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abstracts).*

Water Pollution Control. Tannery Wastes. H. S. MURPHY, J. M. HEPLER and E. F. ELDREDGE. Dept. of Conservation, Dept. of Health, Lansing, Michigan. The first thirteen pages of this eighteen page report consist of a brief summary of the results of experiments with and treatment of tannery wastes during nineteen past investigations and five pages of a condensed report of the operation of the tanner's experiments with tannery wastes at Holland, Michigan. The summary of past experiments with tannery wastes and the conclusions from the present investigation, insofar as they have progressed, indicate the following: Proper combination of the wastes will precipitate out a large portion of the suspended, settleable solids and even dissolved solids. Sedimentation is necessary to remove the solids. The sludge will not digest in the tanks; therefore best results are obtained by frequent drawing. Sludge has a fertilizer value as well as being capable of acting as a neutralizer for the acidity of the soil. Clinker filters appear to provide the best filtering medium. The high oxygen demand of the wastes necessitates some form of secondary treatment. Sand for secondary filtration may be advisable under certain circumstances, but would materially increase the cost of construction and operation.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abstracts).*

Laws Governing Water Pollution Control—Municipal. Anon. Michigan Department of Health, Revision of 1927. This act authorizes the governing body of a municipality to issue mortgage bonds, in excess of the general limits of bonded indebtedness, for the construction of sewage disposal plant and system. These bonds do not constitute a general liability but shall be secured by the property benefited. The act provides for the issuing of a franchise to private corporations for the construction and operation of sewerage systems. Fees may be collected from the property owner by the corporation or by the municipality in the form of taxes. When collected by the municipality, the

corporation is paid on a flat rate basis.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abstracts).*

Swimming Baths: The Dangers of Pollution and the Measures for Prevention. J. GRAHAM FORBES. J. State Med., 35: 595–607 (1927). Chemical Abstracts, 22: 3, 473, February 10, 1928. (Abstracted by J. A. Kennedy.) "Mr. FORBES discusses the various types of infection which may arise from swimming bath pollution. In addition he considered briefly the bacteriological and chemical control, disinfection and importance of maintaining transparency in the swimming bath waters."—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abstracts).*

Proposed Public Baths for Metropolitan Borough of Bethnal Green. A. E. DARBY. Jour. of the American Association for Promoting Hygiene and Public Baths, 9: 1927, 60. The scheme comprises two swimming pools with Turkish, electric and vapor baths, laundry and heating plant, all housed. Pools are designed to comply with the rules for the Olympic games. Water in pools is to be filtered and chlorinated and will have a maximum period of circulation of four hours. During the winter the larger pools will be closed and covered with a floor for dancing and other public purposes. The dressing boxes will fold back under the galleries.—*A. W. Blohm (Courtesy U. S. Public Health Engineering Abstracts).*

The Operation of the Swimming Pool. WM. H. CARY. Swimming Pool Review, Detroit Department of Health, January, 1927. The operator of a swimming pool should be responsible for the temperature of the pool, the pool water, and the rooms that house the pool, the showers, the lockers and for the operation of the pool equipment. Care of the equipment provides for cleaning the hair strainers frequently; attention to the pump motors; replacing alum in the pot for proper coagulation in conjunction with filters, washing the filters at the proper time and in the desirable manner; and proper operation of the water heater.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abstracts).*

Purifying Water in Swimming Pools. Anon. Canadian Engineer, 54: 12, 373, March 20, 1928. A general discussion of water supply for swimming pools and description of St. Jacques Bath, Montreal. The latter is 25 feet wide by 75 feet long and is used for mixed bathing, the majority of the bathers being children. The water is recirculated, being changed completely every ten hours, and is passed through two 60-inch filters and an ultra-violet ray two-lamp sterilizer. The pool is equipped with a suction cleaner.—*A. W. Blohm (Courtesy U. S. Public Health Eng. Abstracts).*

Liability for Unwholesome Water Supply. A. L. H. STREET. The American City, 38: 6, 115–116, June, 1928. This short article reviews seventeen (17) court cases in which action has been brought against municipalities or water companies for the collection of alleged damages resulting from the consumption of unwholesome water, alleged to be due to negligence on the part of these

companies or municipalities. In general, it appears that the court decisions were to the effect that a private company is not a guarantor of the purity or the wholesomeness of water supplied to consumers for drinking purposes, but that it is bound to use reasonable care to discover and guard against the supplies becoming infected with pathogenic bacteria. Municipalities that voluntarily engage in the distribution of water are subject to the same rights and liabilities as private companies in this regard.—*C. R. Cox.*

Filtration Plant Records. HELMAN ROSENTHAL. The American City, 38: 6, 123–124, June, 1928. As water works operators must base their work on the experiments and accomplishments of their predecessors and coworkers, it is necessary that accurate records be maintained of the results of the operation of the plant and of the analyses of samples of water. Frequently such records of past activities are the only protection available for the operator when disease apparently water-borne is prevalent in the communities supplied with the water. Such records have frequently enabled epidemiologists to saddle the blame for such outbreaks upon other causes than water. It is essential, therefore, that laboratory records be carefully maintained, while economy in operation requires the recording of detailed cost data.—*C. R. Cox.*

Meters and Their Setting, Repair and Records. EDWIN W. HOPKINS. The American City, 38: 6, 90–92, June, 1928. This is a detailed description of the practice of the Consolidated Water Company of Utica, N. Y., relative to the installation, maintenance, and reading of meters and the keeping of office records. Examples are given of special forms for use in tabulating the data. The meter department is under the supervision of the consumers service department of the company which, therefore, places the maintenance of service and meters under a single head. Meters are purchased at lowest cost from the company's specifications. It has been ascertained that it is most economical to purchase high grade meters.—*C. R. Cox.*

Development of a Small-Town Water Works. JOHN C. MCNICOL. The American City, 38: 6, 141–143, June, 1928. The experience at Lake Forest, Ill., is used to indicate the fact that the development of small communities requires the modernization of public utilities in order that people may be attracted thither. The fear of excessive costs frequently prevents such improvements being made; but data of costs for an improved water supply system for Lake Forest indicate that proper financing and a program of economy may permit necessary improvements.—*Chas. R. Cox.*

Mitigating Electrolysis of Water-Mains. W. B. BUCHANAN. The American City, 39: 1, 85–86, July, 1928. The electrolytic corrosion of water mains due to stray current is discussed in detail in this article. Advice is given relative to electrolytic surveys of municipalities by the use of recording voltmeters or ammeters. The records of these meters are correlated with traffic conditions on street railway systems, etc., so that current loads throughout the day may be correlated with stray currents in the piping system. Corrections for undesirable electrolysis are set forth in the article which are based upon

the maintenance of electrical potential of the pipe-line below that of the railroad track so that direction of stray currents will be from track to pipe-line rather than the reverse. The use of joints of low electrical resistance in a pipe-line which has been bonded to the negative bus of the railroad circuit would to a great extent eliminate the electrolysis due to stray currents. A survey which indicates the reversal of flow of current in a pipe line, may indicate the advisability of so bonding to the railroad track or to a negative bus at more than one point. Such surveys usually indicate that gas pipes and water pipes should be bonded together to prevent cross-over currents. —*Chas. R. Cox.*

Water Supply of North Tonawanda, N. Y. CARL L. OELKERS. The American City, 39: 1, 131–132, July, 1928. Description of a modern mechanical filtration plant of eight million gallons per day designed capacity which effectively treats the raw Niagara river water.—*Chas. R. Cox.*

Treatment of Water Supply for Iron Removal. E. V. PEDERSEN. The American City, 39: 1, 126–7, July, 1928. This is a brief description of the iron removal plant at Marshalltown, Iowa, which consists of an aërator and a coagulation and sedimentation tank with a detention period averaging six hours, but ranging in practice from three to thirty-two hours, depending upon the momentary rate of flow. The settled water is then filtered at a conventional rate through rapid sand filters. Due to the fact that coagulants are not used, very little supervision is required other than washing the filters every eight days. The operation of the plant involves no additional cost for material or labor over that required to run the pumping station.—*Chas. R. Cox.*

Sources of Municipal Water Supply. The American City, 39: 2, 125–128, August, 1928. A summary of papers presented before the Iowa Water-Works Conference upon Impounding Reservoirs, Rivers, Deep Wells, and Shallow Wells.—*Chas. R. Cox.*

Electrochemical Polarization Process for Prevention of Corrosion in Locomotive Boilers. L. O. GUNDERSON. Ind. Eng. Chem., 20: 866–9, 1928. A theoretical discussion and review of previous electrolytic methods is given. Use of arsenic as a polarizer is recommended. The method used to prevent corrosion is to insert insulated electrodes in the boiler shell, connect to iron anodes which are immersed in the water and extend longitudinally the length of it, and apply a current of 2 volts with 2–3 amperes. The negative pole is grounded to the shell. A soluble arsenic salt is added to the feed water which will produce sufficient arsenic to act as a secondary cathode. Corrosion has been prevented in boilers for nearly four years using this system of protection, unprotected boilers using similar water showing corrosion in less than one year.—EDWARD S. HOPKINS.

Developing Water Supplies in a Region of Bad Water. J. W. PORTER. Railway Engineering and Maintenance, 23: 12, 516–519, 1927, and Ry. Age 83: 25, 1217–18, 1927. Unsatisfactory well water supply through the Canadian Northwest forced the Canadian National R. R. to construct reservoirs suffi-

ciently large to hold the spring "run-off" for heavy summer and fall use after a winter of the lightest probable snowfall. Earth dams were used with carefully built spillways and scour pipes. Several reservoirs required foul water ditches to prevent contamination by normal flow of highly impregnated alkali waters.—*R. C. Bardwell (Courtesy Chem. Abst.)*

Better Pumps Cut Operating Costs. Anon. Railway Engineering and Maintenance, **24**: 1, 7–10, 1928. The Chesapeake and Ohio Ry. recently reconstructed the large pumping and water treating plant at its Stevens, Ky., terminal. The Ohio River water which frequently carries heavy sediment is treated and settled first in a 30-foot diameter by 80 feet high flat bottom steel tank at rate of 1,500 gallons per minute with 16 feet per hour vertical velocity and then through second tank 40 feet in diameter by 70 feet high with floating outlet. Hydrated lime, soda ash, and sodium aluminate are used. Centrifugal pumps driven by 120 h.p. oil engine with vertical belt drive and electric motor stand-by, with dry well and intake provisions are featured.—*R. C. Bardwell (Courtesy Chem. Abst.)*

Maintenance of Water Treating Plants. Com. Rep. Railway Engineering and Maintenance, **23**: 11, 480–482, and Ry. Age., **83**: 18, 834–836, 1927. Less than one-third of the water used by locomotives is being given proper attention. Orderliness and cleanliness are of first importance and proper check system is essential.—*R. C. Bardwell (Courtesy Chem. Abst.)*

Illinois Central Cleans Well Screens With Acid. C. R. Knowles. Railway Engineering and Maintenance, **24**: 5, 202–204, 1928. The Ill. Cent. R.R., recently cleaned the screen in an 18-inch well 258 feet deep at Pesotum, Ill., with commercial HCl, using 800 gallons acid to form 30 per cent solution. The acid was allowed to stand in well 24 hours before pump was started and well thoroughly flushed. Yield was increased from 42 to 140 gallons per minute.—*R. C. Bardwell (Courtesy Chem. Abst.)*

Louisville & Nashville Meets Problem of Greater Water Supply. F. H. Kornfield. Railway Engineering and Maintenance. **24**: 2, 51–54, 1928. The L. & N. R. R. obtains water supply for its Memphis freight terminal at Leewood, Tenn., from well approximately 300 feet deep, of which 110 feet is 16-inch and balance, 15-inch diameter. Approximately 55 feet of keystone wire wrapped strainer was used with openings varying from 0.012 to 0.016. Well capacity is 700 gallons per minute with 11 feet drawn down. Three stage vertical centrifugal pump is operated by 30 h.p. motor. Station is equipped with Venturi recording meter and electric hoisting equipment for overhauling well.—*R. C. Bardwell.*

Feedwater Heaters Reduce Pitting. C. H. Koyl. Railway Age, **84**: 11, 629–630, 1928. Weekly examination over a period of thirty months of flues in locomotive boiler equipped with open type feedwater heater operating between Sioux City, Ia., and Mitchell, S. D., on the C. M. & St. P. Ry., developed practical absence of pitting while similar locomotives not so equipped pitted

badly. Test indicates that elimination of oxygen by open type locomotive feedwater heater will greatly retard boiler corrosion in water carrying high alkali salts which otherwise pit although NaOH is present. In addition, the fuel saving averaged $1,000 per year.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

The Full Cost of Water Treatment. Railway Age, **85**: 3, 93, 1928. Expense of water treatment should include anti-foaming compounds required by additional alkali salts introduced.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Circulating System in the Coffin Feedwater Heater. Anon. Railway Age, **84**: 24A, 1420–40, 1928. Diagram and method shown for installing and operating feedwater heater on locomotive.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

New Water Supply Facilities Effect Economies on the Southern. Anon. Railway Age, **84**: 23, 1329–1332, 1928. The Southern Ry. recently completed extensive improvements to the Yadkin River plant at their Spencer, N. C., terminal. A 2,500,000 gallon sedimentation basin is provided with facilities for alum and dry sodium aluminate treatment. Present consumption averages 1.3 m.g.d. Automatic electric control is provided for raw water and transfer pumps.—*R. C. Bardwell* (*Courtesy Chem. Abst.*)

Grand Canyon Pumping Plant Lifts Water 3,870 feet. Anon. Railway Engineering and Maintenance, **24**: 7, 287–291, 1928. The Union Pacific Railroad has completed a pumping station on the Colorado River in Arizona which supplies water to Bright Angel Point on the north rim of the Grand Canyon. Triplex pumps with 50 h.p. motors are used to deliver 30 gallons per minute against a static head of 3,870 feet through 3½-inch discharge line, which varies from standard w. i. pipe to extra heavy seamless pipe with the pressure requirements. Power is furnished from 81.25 k.v.a. generator in bottom of canyon which is operated by water power through 2,640 feet of 26-inch wood stave pipe with fall of 237 feet. Construction was exceedingly difficult, due to inaccessibility, but results have proven very satisfactory. Photographs, contour map, and profile chart, are shown.—*R. C. Bardwell.*

Drinking Water Conditions on Railroads During the Mississippi Flood. Com. Rep. Amer. Ry. Engr. Assoc. Proceed., **29**: 126–130, 1928. Emergency liquid chlorine treatment was installed in larger towns by State Health Departments. Railroads issued bulletins recommending treatment of small supplies with calcium hypochlorite on basis of one ounce per 1,000 gallons. Boiling water was not found reliable. Experienced supervision was provided where possible.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Causes of Boiler Pitting and Means of Prevention in Neutral and Alkaline Waters. C. H. Koyl. Amer. Ry. Eng., Assoc. Proceed., **29**: 131–133, 1928. General review.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

The Prevention of Boiler Pitting in Neutral and Alkaline Waters by the Exclusion of Dissolved Oxygen from the Feedwater. C. H. KOYL. Amer. Ry. Engr. Assoc. Proceed., **29**: 133–135, 1928. Operation of locomotives equipped with open feed water heater in the alkali water district on the C. M & St. P. Ry. during past three years has shown good results in reduction of pitting and corrosion compared with similar engines in similar service not so equipped. Average dissolved oxygen removal was 60 per cent. Inaction of balance is accounted for by surge of water in locomotive boiler. Details and regularity of operation are important.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Prevention of Pitting and Corrosion by Electrochemical Polarization. L. O. GUNDERSON. Amer. Ry. Engr. Assoc. Proceed., **29**: 135–139, 1928. Three years test on the Chicago and Alton Railroad, with electrochemical polarization system installed in locomotive boilers, using weak arsenic solution and 2-volt electric current with 0.001 to 0.002 ampere per square foot of protected surface, has shown good results in relieving pitting and corrosion conditions. —*R. C. Bardwell (Courtesy Chem. Abst.).*

Sodium Aluminate as an Aid to Water Softening. Com. Rep. Amer. Ry. Engr. Assoc. Proceed., **29**: 138–139, 1928. Sodium aluminate, used in the lime-soda process of water softening, hastens reaction time, improves coagulation and sedimentation, and reduces trouble from after-precipitation. Experiments are being conducted with dry sodium aluminate.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Use of Sodium Aluminate on the Rock Island Lines. PAUL M. LABACH. Amer. Ry. Engr. Assoc. Proceed., **29**: 139–142, 1928. Tabulation of results and analyses indicates that advantages gained by use of sodium aluminate are: (1) increased plant capacity; (2) less residual hardness in treated water with smaller lime-soda overtreatment; (3) less alkali salts in treated water with reduction in locomotive foaming complaints; (4) reduction in after-precipitation and improvement in pipe line conditions. At 25 plants sodium aluminate is used without addition of lime or soda ash.—*R. C. Bardwell (Courtesy Chem. Abst.)*

Foaming of Locomotive Boilers with Special Reference to the Influence of Suspended Matter on Foaming and Cost of Blow-down. Com. Rep. Amer. Ry. Engr. Assoc. Proceed., **29**: 143–152, 1928. General review, with charts and tables, indicates that foaming in locomotive boilers will vary with type, character, and amount of suspended solids, and also with the type of work being handled by the locomotive.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Cost of Blow-Down of Locomotive Boilers. R. A. TANNER. Amer. Ry. Engr. Assoc. Proceed., **29**: 152–155, 1928. Foaming point must be determined for individual district and conditions after which amount of blow-down and cost can be calculated. Formula and chart are included.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Carbonate and Sulphate Waters. Their Relative Influence on the Operation and Maintenance of Boilers and Their Comparative Costs of Purification. Com. Rep. Amer. Ry. Engr. Assoc. Proceed., **29**: 156–157, 1928. Cost per pound for treatment varies from 0.44 cent for $CaCO_3$ to 1.66 cents for $MgSO_4$. Cost in blow-down water for Na_2SO_4 averages 4 cents per pound and soft sludge and suspended matter about one cent per pound unless blown out by necessity for reducing alkali concentration.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Disposal of Sludge at Water Softening Plants. Com. Rep. Amer. Ry. Engr. Proceed., **29**: 187–193, 1928. Where low land or flowing stream is not available, accumulation in pits with periodic cleaning and removal or direct removal in specially designed sludge cars is necessary. Plans and diagrams of typical installations are shown.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Economical Spacing of Water Stations in Connection with Increasing Capacity of Engine Tenders. Com. Rep. Amer. Ry. Engr. Assoc. Proceed., **29**: 194–196, 1928. The increase in maximum water capacity of locomotive tenders during past few years from 9000 to 22,000 gallons is having a marked influence on satisfactory railway water station spacing. Consideration and study of individual engine districts is necessary to determine economies involved.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

The Value of Boiler Water Treatment to the Mechanical Department. J. F. Raps. Amer. Ry. Engr. Assoc. Proceed., **29**: 1022–24, 1928. Review of improvements effected on the Ill. Cent. R. R., by water treatment.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Water Treatment from the Standpoint of Railroad Efficiency. E. M. Grime. Amer. Ry. Engr. Assoc. Proceed., **29**: 1014–21, 1928. General review of water treatment for railways.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

The Treatment of Water for Locomotives from the Standpoint of Chemical Engineers. W. M. Barr. Amer. Ry. Engr. Assoc. Proceed., **29**: 1025–31, 1928. General discussion of railway water treatment problems including compounds, lime-soda, and zeolite methods.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Boiler Feed Water Treatment from a Manufacturer's Viewpoint J. B. Romer. Amer. Ry. Engr. Assoc. Proceed., **29**: 1032–37, 1928. General review of boiler feed water impurities and their effect.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Sedimentation With and Without Chemicals, Pressure and Gravity Filters, Deconcentrators, and Continuous Blow-Down Apparatus. Com. Rep. (R. C. Bardwell) Amer. Ry. Engr. Assoc. Proceed., **29**: 1038–44, 1928. Review of present conditions.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Pretreatment of Boiler Feed Water. Comp. Rep. (C. R. KNOWLES) Amer. Ry. Engr. Assoc. Proceed., **29**: 1045–51, 1928. Review of lime-soda and lime-soda-zeolite methods.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Present Knowledge of Foaming and Priming of Boiler Water, with Suggestions for Research. Com. Rep. (C. W. FOULK) Amer. Ry. Engr. Assoc. Proceed., **29**: 1052–61, 1928. General review of known causes and theories for boiler foaming.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Embrittlement of Steel. Com. Rep. (ALEXANDER G. CHRISTIE) Amer. Ry. Engr. Assoc. Proceed., **29**: 1062–74, 1928. General review of controversy on effect of various mineral constituents in boiler feed water on the embrittlement of boiler metal indicates need for further study and research.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Proceedings of the Third Annual Conference on Water Purification. Technical Bulletin No. 1: Engineering Experiment Station, West Virginia University, Morgantown, W. Va. A series of papers on water purification. Establishing classifications of public water supplies in West Virginia. The significance of the colon bacillus in water; its relationship to the typhoid organism; tests for *B. coli*. Elimination and recovery of phenols from by-product coke oven wastes as done at Fairmont. Tastes and odors in water supplies, with special reference to waste liquors from by-product coke plants. The use of pH control in a sanitary laboratory. Water softening on a large scale by zeolite process. Descriptive article on the four million gallon zeolite water softening plant of the Ohio Valley Water Company at McKees Rocks, Pa. Wheeling filtration plant operation data and costs. Two years and a half of detail records of operation of this plant. Improvements in equipment and technique of operation of chlorine disinfection apparatus.—*L. V. Carpenter.*

Further Observations on the "Symbiotic Fermentation Phenomenon." Its Use in the Differentiation of Certain Micro-Organisms and in the Identification of Certain Carbohydrates.—ALDO CASTELLANI. Sixteenth Annual Report, Medical Dept. United Fruit Company, pp. 200–13. 1927. Two microörganisms, neither of which alone produces fermentation with gas in certain carbohydrates, may do so when living in symbiosis or when artificially mixed. The phenomenon was noted in 1904 in connection with certain yeasts. Experiments since then have included pathogenic bacteria. The phenomenon takes places only when certain germs are used and may be put in evidence by using either liquid or solid media. Broth should not be used as it contains glucose; sugar-free peptone should be used instead. The phenomenon may be used in the differentiation of certain organisms and in the identification of certain carbon compounds. The author offers to supply workers interested in the subject with cultures of the various strains of bacteria and fungi used in his experiments.—*John H. O'Neill.*

A New Agent for Water Sterilization. Anon. Note. The Military Surgeon, **63**: 123, July, 1928. Brief review of use of chlorine compounds for treating potable water in field stresses deterioration in strength of bleaching powder, even when kept in sealed glass tubes. A board representing the Chemical Warfare Service and the Medical Department has under consideration a number of compounds, including *p*-dichloraminosulfonbenzoic acid, better known as "halozone." This agent is quite stable and has satisfactory bactericidal properties in dilutions somewhat less concentrated than is feasible with calcium hypochlorite. [This compound was used and distributed by the Louisiana State Board of Health during the 1927 flood.—ABSTR.]—*John H. O'Neill.*

Stream Pollution. Self-Purification of Streams. H. W. STREETER. Southwest Water Works Journal, **10**: 17–20, July, 1928. A discussion of the principles involved in the self-purification of streams and of methods of quantitative measurement of effects, based upon the Studies of the United States Public Health Service.—*John H. O'Neill.*

A Comparison of the Results of Clemesha's Method and the Test of Citrate Utilization as applied to Water Supplies in Burma. J. TAYLOR, assisted by C. de C. MARTIN, J. V. R. & P. N. R. NAIDU. Indian J. M. Res., **14**: 801–36. From Bull. Hyg., **3**: 273, April, 1928. In assessing the value of *B. coli* as an index of sewage pollution, Clemesha set up groups based on the relative rapidity of disappearance from water of different species of the organism. More recent investigators have differentiated the organisms on the basis of normal habitat. On this method of differentiation, the MR and VP tests are based. Contradictions from these two tests caused the utilization of Koser's citrate test also. In this paper, the relative values of Clemesha's classification and the MR, VP and citrate tests on Burmese waters are compared. It is concluded that the latter tests give much information; but that, using either method alone, the Clemesha technique gives results which correlate more closely with sanitary survey.—*Arthur P. Miller.*

The Value of Methods for the Differentiation of Bacilli of the Coli-Aërogenes Group, when applied in Shanghai. E. P. HICKS. J. of Hyg., **26**: 357–61. From Bull. Hyg., **3**: 274, April, 1928. Examination was made of 200 organisms of the coli-aërogenes group; 100 human, 50 animal, 150 human and animal, and 50 soil. Citrate, indol, MR and VP tests were made. A table shows results in percentages. The conclusion is that in the vicinity of Shanghai, MR and VP tests are of little value, but indol and citrate tests do give indications of excremental pollution.—*Arthur P. Miller.*

A New Agar-Dye Differential Medium for the Colon-Typhoid Group. With Special Reference to its Use in Water Analysis. A. J. SALLE. J. Infect. Dis., **41**: 1–8, 1 graph. From Bull. Hyg., **3**: 274, April, 1928. A new medium which differentiates the *B. coli* from the aërogenes group at plating stage is described as having the following composition:

Peptone (Difco)	5 grams.
K_2HPO_4	5 grams.
KH_2PO_4	1 grams.
Distilled Water	1,000 cc.
Agar	20 grams.

Adequate buffering and the use of indicators giving marked color changes over the desired pH range are required. Method of preparing medium is given.—*Arthur P. Miller.*

Protozoa in the Water Tanks of Steam Ships. N. L. WIBAUT-ISEBREE MOENS. Nederl. Tjischr. v. Hyg. Microbiol. en Serol. (Leyden), **2**: 24–43, 16 figs. From Bull Hyg., **3**: 275–276, April, 1928. Gastro-intestinal troubles are more often found on small boats carrying relatively little drinking water than on large vessels which carry large quantities of water much of which is untouched for many days. The writer investigated this matter and ascribes as the reason for it the bacteriophagic action of protozoa. In water on the large vessels which was untouched for a fortnight, *Cyclidium glaucoma* and *Glaucoma scintillans* were found strongly bacteriophagic, causing disappearance of practically all bacteria. Based on the above, the author suggests that it would be better not to chlorinate such water because the protozoa would be killed, thus precluding their later disinfecting action.—*Arthur P. Miller.*

Principles of Sterilization of Drinking Water by Chlorine Gas. G. LUTZ. Ztschr. f. Hyg. u. Infektionskr., **107**: 585–91. From Bull. Hyg., **3**: 276, April, 1928. The author sets forth data to substantiate his conclusion that the sterilizing effect from chlorine should not be ascribed to the nascent oxygen released in the chemical action but to the direct action of the chlorine or hypochlorous acid. In chlorination, from the sixth to twenty-fourth hour, active chlorine content is reduced and a corresponding amount of nascent oxygen formed. Hence on the nascent oxygen theory, sterilization should have progressed. This was not true, for the organisms showed an increase. —*Arthur P. Miller.*

Purification of Water by Filtration. J. W. WOLFF. Meded. v. h. Path. Lab. te Medan-Sumatra, **2**: 15 pp. From Bull. Hyg., **3**: 277–278, April, 1928. The author recommends the "Noritfilter" for domestic use. Norit is a preparation of finely divided charcoal. At Medan, dirty river water was purified through one of these filters for two and one half months, about 100 pints of sterile water being obtained daily. For chlorination, a Bayer compound called "Caporit," said to contain 50 per cent available chlorine, is suggested. It does not decompose in the tropics and is easily soluble in water.—*Arthur P. Miller.*

Dorr Impeller Water Agitator. A. ANABLE. Canadian Engineer, **53**: 517. From Bull. Hyg., **3**: 280, April, 1928. A brief description of device listed in title. Agitator is designed to give efficient mixing of chemicals with water. —*Arthur P. Miller.*

The Problem of Rural Water Supplies. J. J. PATERSON. J. State Med., 35: 535–40. From Bull. Hyg., 3: 281, April, 1928. Describes limitations of the Act of 1878 which provides that dwellings must have an efficient water supply. In order to avoid financial losses, water companies do not extend into non-profitable areas and many dwellings must have wells; later, extensions are made and the home owner, being compelled to connect, suffers the loss of the well cost. Rival companies having rights in certain areas cause further conflicts. Territorial water boards having as jurisdictional area natural watershed units and modeled on the Thames Conservancy are advanced as being more suitable.—*Arthur P. Miller.*

Rural Water Supplies—the Advantages of Decentralisation. D. F. WORGER. Surveyor, 72: 513–14. From Bull. Hyg., 3: 4, 281–2, April, 1928. The Bruston auto-pneumatic water supply system is advanced as being very suitable for small communities because the pumping is automatically controlled to give a constant head in the delivery main. The system is also suitable where it is necessary to use a number of small and independent water sources.—*Arthur P. Miller.*

The Pollution of Streams and other Natural Waters of Australia. F. F. LONGLEY. Commonwealth of Australia. Dept. of Health. Service Publication. 24: 35 pp. From Bull. Hyg., 3: 4, 282, April, 1928. In an educative pamphlet with six appendices, the problem of stream pollution in Australia is discussed. At the present time control is subject only to common law. The writer points out that as development of country proceeds, the problem will become more acute; hence the necessity for adequate control from the outset.—*Arthur P. Miller.*

Sterilization of Drinking Water by "Aquapurol." A. MÜLLER. Ztschr. f. Hyg. u. Infektionskr., 108: 27–37. From Bull. Hyg., 3: 277, April, 1928. A description of "Aquapurol," aqueous chlorine solution sold in ampullas for disinfecting water. Tests of product not yet satisfactory as chlorine content of ampullas is found to vary.—*Arthur P. Miller.*

Estimation of Corrosive Carbonic Acid in Natural Waters. K. GELINEK. Gesundheits-Ingenieur, 50: 875–9. From Bull. Hyg., 3: 284, April, 1928. This article records researches by which the authors, TILLMANS and HEUBLEIN, "have made determination of the limiting concentration in which free carbonic acid may coexist with given quantities of half-bound carbonic acid without giving a corrosive water."—*Arthur P. Miller.*

Ghosts of the Past Still Linger Today. ROBERT E. MCDONNELL. Water Works Eng., 81: 12, 777, June 6, 1928. Improved water works equipment gives increasingly high efficiencies. Improvement is not always a matter of replacing old equipment, but involves study of water supplies, silt removal, water purification, better methods of distribution, equalizing reservoirs, avoiding high peak loads. When sedimentation basins with aid of coagulants are used to clarify water, they must be cleaned by sluicing and washing

which is expensive. They are being displaced by smaller and less expensive clarifiers from which sediment is constantly removed through a bottom center outlet. Tests show removals as high as 95 per cent; a high efficiency at a reduced cost. Same improved methods can be used for removing sludge from water softening and sewage treatment plants. High grade centrifugal pumps deliver water at the lowest total cost. Progress of the geared turbine-driven centrifugal pumps since first used sixteen years ago has been rapid. Automatically operated pumping equipment is proving very satisfactory and economical. Small diameter driven wells, too small for an efficient pump and low in water production are fast giving way to bored wells, 24-inch to 48-inch diameter, with concrete screen surrounded with a gravel wall; accommodating multi-stage pumps of high efficiency, with pump bowls below and not above the best water bearing formation. Screen clogging is less and water yield per well, greater. The use of Diesel oil engines is rapidly growing. Their economy has been fully proved in smaller lighting plants. One of the worst ghosts of the past, is the tendency to run water works plant as a political rather than a business institution. A non-political board of high-class business men selected for a long term with a continuity of policy is the surest way to successful waterworks operation.—*Carl Speer, Jr.*

Are the Desmids Troubling You? P. D. Strausbaugh. Water Works Eng., **81**: 15, 1039, July 18, 1928. Desmids form one of the characteristic groups of green algae. They are small microscopic growths of endless variety in outline and pattern and are very likely to occur in every water supply. Environmental factors affect the growth and distribution of algae, but knowledge of how and why is unsatisfactory. The water works engineer should know the reactions of these plants, particularly how they affect the water in which they grow. Algae are responsible for odor and taste in water; pure water is odorless and tasteless. The odors are generated by the production of vegetable oils within the organism. Common odors encountered are: aromatic, grassy, fishy. Diatoms are chiefly responsible for first; blue-greens for second; and certain of green algae for third and worst. In small reservoirs a floating roof which will exclude light will prevent growth of algae, but is expensive. Chemical treatment has proved effective in certain cases. Application of copper sulphate is most popular method in use today. The most successful method, however, is filtration with aëration. The best remedy for a clogged filter medium is intermittent filtration. Aëration provides for the elimination of odorous gases.—*Carl Speer, Jr.*

Taking Corrosion Out of Catskill Water. W. W. Brush. Water Works Eng., **81**: 13, 915, June 20, 1928. Catskill system daily furnishes New York with 600 or more million gallons. Its corrosive effect on iron is rapid. Cast iron pipe removed after nine years use is found to be filled with iron rust tubercles as large and numerous as would be found in pipe carrying Croton water for forty years. When hot water supply is above 160°F. pipes clog in a few years. Cold water supply pipes would not clog for ten years. Treatment was begun April 2, 1928. Soda ash is added to water at Hillview reservoir at rate of one-half grain per gallon pending further experiments. Soda ash is

delivered in 200-pound bags, and a quarter of a bag dumped into the water at proper intervals; about every two minutes. So far, the pH has been raise from 6.7 to 8.4; the alkalinity, from 8 to 15. Tests are made weekly at 5 buildings to determine change in corrosive properties of the water. Other tests are made at Ashokan reservoir gate house. Seven wooden tanks have been erected with pipe lines of lead, steel, wrought iron, and brass, with devices to heat the water. Samples are taken at several points. It is too early as yet to give out definite results.—*Carl Speer, Jr.*

Safety in Dam Construction. F. JOHNSTONE-TAYLOR. Water Works Eng., 81: 15, 1035, July 18, 1928. Four main methods of dam construction are: (1) earthen bank with puddle or concrete core, (2) masonry or mass concrete dam, (3) arched dam, (4) buttressed dam. For structures of moderate height, ferro-concrete proves economical as it can be built on buttress and panel principle. The arch dam is stable against water pressure by reason of its arch effect, while mass concrete is stable because of its bulk, providing a downward resisting moment greater than the horizontal over-turning moment of the water. Particulars, dimensions, and diagrams given amply explain the following structures: Great Lakes Dam in Tasmania; Swedish dam across the Great Lule River; Tirso dam in Sardinia; Ambursen type dam at Junction Brook, Newfoundland; Sherman Island dam on Hudson River; Lake Eleanor dam of the San Francisco Water Works.—*Carl Speer, Jr.*

Effects of Water on Teeth in Europe. FREDERICK S. MACKAY. Water Works Eng., 81: 15, 1037, July 18, 1928. In Pozzuoli, a suburb of Naples, an enamel lesion on the teeth was freely produced. Inhabitants of this district were distinguished from their neighbors by their black teeth. After a change in water supply had been made several years ago no more cases appeared. In the neighboring town of Resina, which is practically at the foot of Vesuvius, at the time of investigation (1927) mottled condition of teeth was found only in adults. The water supply had been changed from the wells formerly used to a supply piped from the slopes of hills adjacent to Vesuvius. Adults had grown the enamel on their teeth at a time when well water was being used, while the younger generation which is immune had grown their enamel using piped-in-water. Just outside Resina, where people are engaged in farming small plots, typical illustrations of the defect in enamel are found. The teeth are mottled and black. The water supply is derived from wells sunk as far back as 300 to 500 years ago in underlying lava from volcanic eruptions. Not one person who used the water from these wells during the enamel growing period escaped enamel defect. The next important step is to determine the chemical peculiarity common to these waters regardless of origin. In many endemic districts the waters of surface origin bear no relation to deeper strata. —*Carl Speer, Jr.*

ABSTRACTS, SUBCOMMITTEE NO. 9

Joint Research Committee on Boiler Feedwater Studies

Boiler Explosion Inquiries. Engineering (Lond.), **126**: 3265, August 10, 1928, p. 183. Summary of inquiries recently conducted by (British) Board of Trade; fracture of blowdown valve; failure of cast-iron, lead-lined still; explosion from cast-iron steaming box; rupture of stop-valve chest on S. S. "Araguaya;" explosion of water-tube boiler; explosion of main boiler on steamer; fracture of safety-valve chest; explosion from cast-iron pipe.

Boiler-Corrosion Problems. F. N. Speller. Fuels and Steam Power (A. S. M. E. Trans.), **50**: 15, May–August, 1928, pp. 222–223. Progress report of Sub-Committee No. 5 on corrosion of boilers and effect of treated water in accelerating or relieving these troubles.

Corrosion of Boilers Checked by Electrochemical System. O. W. Garrick. Eng. News-Rec., **101**: 6, August 9, 1928, p. 209. Summary of paper on electrochemical polarization system that has given satisfactory restuls when applied to locomotives and is said to be applicable also to boilers of water works and other utility and industrial plants; flow of electric current is maintained in boiler, with arsenic in water; trials show good results.

Removing Air From Boiler Feed Line. W. E. Warner. Power, **68**, 8, August 21, 1928, p. 325, 1 fig. Account of trouble due to collecting of air in one of boiler feed lines which was overcome in power station of London Hydraulic Supply Co., by installing air separator connected to feed line.

Evaporators for Boiler-Feed Make-Up Water. W. L. Badger. Fuels and Steam Power (A. S. M. E. Trans.), **50**: 15, May–August, 1928, pp. 207–212, 6 figs. Author without going extensively into design of multiple-effect evaporators, attempts to cover few matters which he believes are not generally understood: namely, effect of certain factors on rates of heat transfer; rationale of form and entrainment; mechanism of scale formation; and, briefly, wide ranges in performance which may be obtained by varying what are ordinarily considered minor factors in evaporator operation.

Bibliography. G. A. Stetson. Fuels and Steam Power (A. S. M. E. Trans.), **50**: 15, May–August, 1928, pp. 226 and (discussion) 227–230. Report of Sub-Committee No. 9. Most of material has been furnished by Engineering Index.

Cost of Feed-Water Equipment for Eastern Station. Elec. World, **92**: 5, August 4, 1928, p. 216. From construction cost records of an Eastern central station are taken data bearing upon plant extension carried out during 1925 in connection with feedwater equipment.

River Water for Boiler Feed (Aufbereitung und Verwendung von besonders salzhaltigem Flusswasser). K. HOFER. Glueckauf (Essen), **64:** 21, May 26, 1928, pp. 669–672, 2 figs. Waters of Lippe in Ruhr district contain relatively high percentage of easily soluble salts and are, moreover, very variable in composition; they are used for boiler feed in certain number of plants, and author presents typical analyses of water, together with notes on deposits and corrosion observed, and operating data relating to treatment and use of water. See brief translated abstract in Power Engr. (Lond.), **23:** 269, August, 1928, p. 326.

Boiler Feedwater Purification, The "Neckar" System. FLUX, G. J. Het Gas **48:** 115–22, 1928. Chem. Abstracts, July 10, 1928, **22:** 13, 2422. The "Neckar" system here described consists of a treatment with soda in the heat; the alkalinity used was between 5 and 10 cc. 0.1 N HCl per 50 cc. water (0.3° Be). Deposits found in a waste heat boiler after prolonged use consisted mainly of SiO_2 (from colloidal Na_2SiO_2). It is calculatd that by a 7.2 per cent blowdown this danger can be avoided.—*B. J. C. Van der Hoeven.*

Deconcentrating Treatment of Boiler Water. H. L. GRIFFIN. Power Plant Eng., **32:** 16, August 15, 1928, pp. 869–870, 2 figs. Impurities in feedwater accumulate in boilers, causing troubles which may be prevented by continuous blowdown.

Foaming and Priming, Internal-Treatment, and Behavior of Zeolite-Softened Waters. C. W. FOULK. Fuels and Steam Power (A. S. M. E. Trans.), **50:** 15, May–August, 1928, pp. 219–222. Progress report of Sub-Committee No. 3 on zeolite softeners, internal treatment, and foaming.

Treatment of Feed Water. CAREY, W. G. Fuel Econ. Rev. **6:** 36–9, 1927. Chem. Abstracts, July 20, 1928, **22:** 14, 2630. A review.

New Indicating Equipment for Industrial pH Measurements. H. C. PARKER. Indus. and Eng. Chem., **20:** 7, July, 1928, pp. 676–680, 4 figs. Three new potentiometers are described which are suitable for making industrial H-ion measurements; two of these have scales which are direct reading pH; technic required for making measurements with industrial types of quinhydrone and hydrogen electrodes is described; limitations regarding use of quinhydrone electrode and relative suitability of H-ion and conductivity measurements are discussed.

Annual Meeting of Society of German Chemists, etc. (Hauptversammlung des Vereins deutscher Chemiker in Dresden). Gas- und Wasserfach (Munich), **71:** 27, July 7, 1928, pp. 661–666. Abstracts of papers on coal and water chemistry presented at Dresden meeting of May 30 to June 3, 1928.

Water Softening at Hinsdale. H. MENOLD. Pub. World, **59:** 8, August, 1928, pp. 301–302. Description of modern equipment, including mechanical agitation, dry feed, clarifier for continuous sludge removal and carbon-dioxide

machine; sodium aluminate used; few complaints from users of water leads author to conclude that for household and drinking purposes water works is supplying finished product that is generally satisfactory. Paper read before Am. Water Works Assn.

NEW BOOKS

Handbuch der Wasserversorgung. ERWIN GROSS. Abteilungsleiter der Landesanstalt für Wasser-, Boden- und Luft Hygiene in Berlin-Dahlem. Mit 187 Abbildungen. Verlag von R. Oldenbourg, München und Berlin, 1928. Reviewed in Engineering News-Record, **101**: 16, 595, October 18, 1928.

The principles and technology of water supply development have been elaborated to such a degree in the past twenty years that it is doubtful whether any author can do justice to the entire subject in as brief a discussion as one volume, aggregating as in this case some 400 pages of text. A bird's eye-view of a field of endeavor and a technical source book are not synonymous. The present volume suffers from the disabilities of any short handbook, namely, uneven balance of subject matter, omission of important principles and facts and compression of data within too limited a space. In spite of these disabilities, the volume is surprisingly interesting and valuable in that it presents certain topics in comprehensive manner and in a fashion not easily available in American texts. Like most foreign texts, on the other hand, it consistently ignores American practice, even where the latter is helpful and perhaps more advanced than the foreign, as, for example, in the carefully developed programs of chlorination control in the United States.

The author has attempted to cover the field of water supply, by discussing basic principles of selection of source, development of underground and surface supplies, collection of water, treatment, distribution and pumpage. Unusually excellent, though brief, discussion is given on the problem of predicting water consumption. The author recognizes a factor of importance, frequently ignored in the United States, and exemplified in his statement: "Water consumption is in an important degree a measure of the standard of living of the people." His data on per capita water consumptions in German cities are instructive.

Similarly helpful discussion is given of hydrogen-ion concentration, iron and manganese removal, aggressivity and aeration. As a matter of fact, these topics are more completely and carefully handled herein than in most water supply texts. Instructive graphical methods are presented for determining aggressive CO_2 and for estimating the precipitation possibilities for iron and calcium in different chemical complexes. Other important phases of treatment are not so generally useful, although worth-while for comparisons with American practice. The discussion of chlorination is inadequate, from the standpoints of general application, of control and of principles of reaction. The only free chlorine indicator mentioned is benzidine. Chloramine treatment receives 4 lines of discussion, while ozone is covered in 3 pages.

As usual in German texts, the question of underground water supply development is handled at length and with much mathematical detail. These

sections deserve careful review, because they contain a number of interesting suggestions on deep well construction. Some of the types of well construction are reminiscent of that recently constructed at Amarillo, Texas, to provide for automatic gravel replacement of sand.

The sections on pumps and dams are necessarily too short to do any more than present general principles. The reviewer doubts the wisdom of even including the subject of dams, for example, when earth dams are dismissed in less than 10 pages.

In general typography, the book is excellent. It is well illustrated and carefully indexed; and has an unusually good table of contents. A bibliography of 92 references is appended, of which two are published in the United States.—*Abel Wolman.*

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DEC 29 1928

VOL. 20, NO. 6 DECEMBER, 1928

PROCEEDINGS 47TH YEAR

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

PUBLISHED MONTHLY

BY THE

AMERICAN WATER WORKS ASSOCIATION

AT MOUNT ROYAL AND GUILFORD AVENUES, BALTIMORE, MD.

SECRETARY'S OFFICE, 29 WEST 39TH STREET, NEW YORK
EDITOR'S OFFICE, 2411 NORTH CHARLES STREET, BALTIMORE, MARYLAND

Subscription price, $7.00 per annum

Entered as second class matter April 10, 1914, at the Post Office at Baltimore, Md., under the act of August 24, 1912
Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917;
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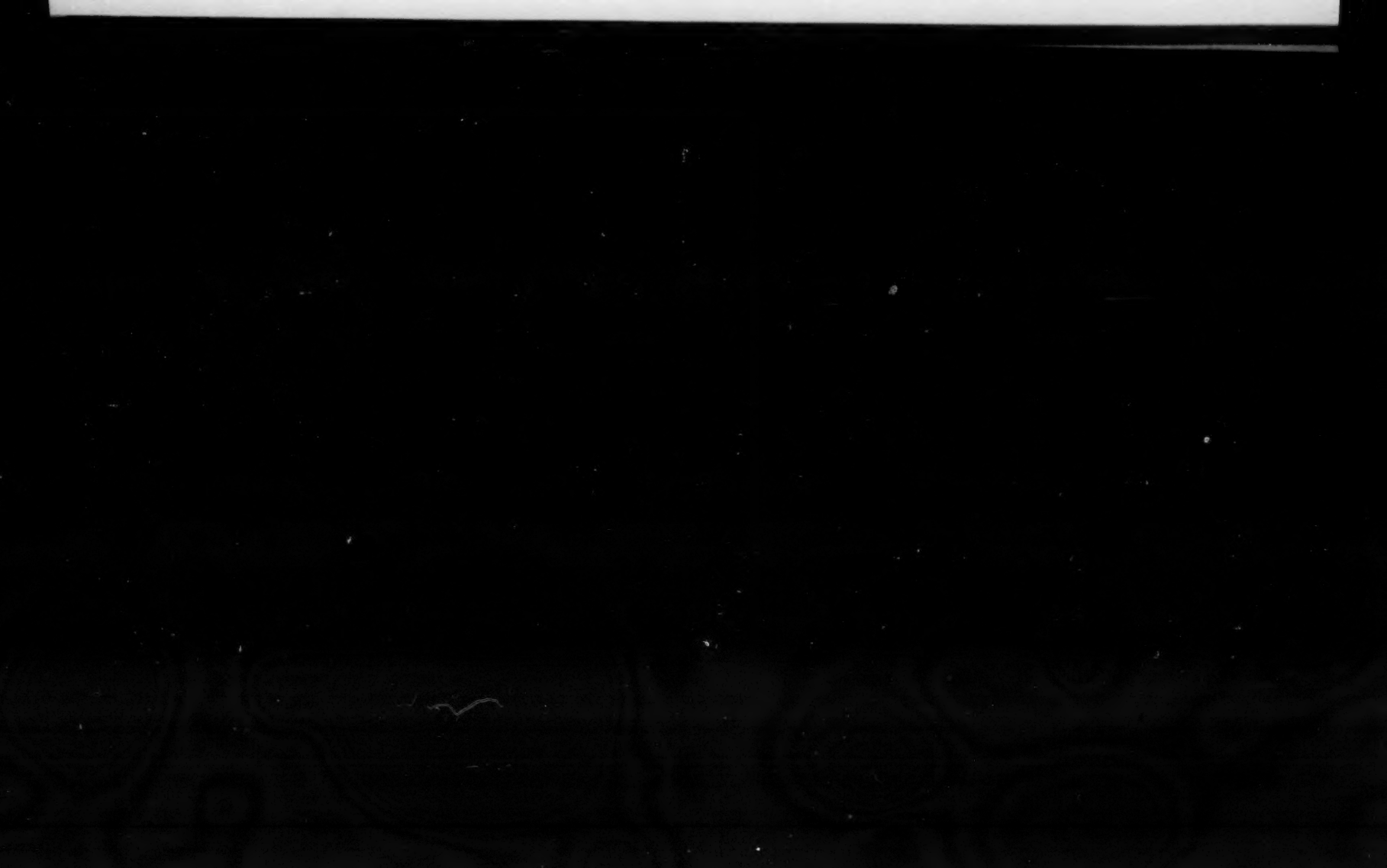

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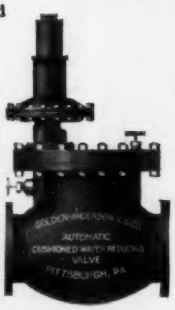

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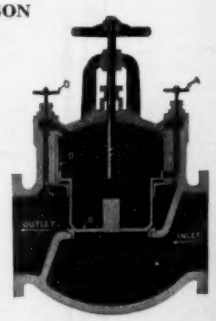

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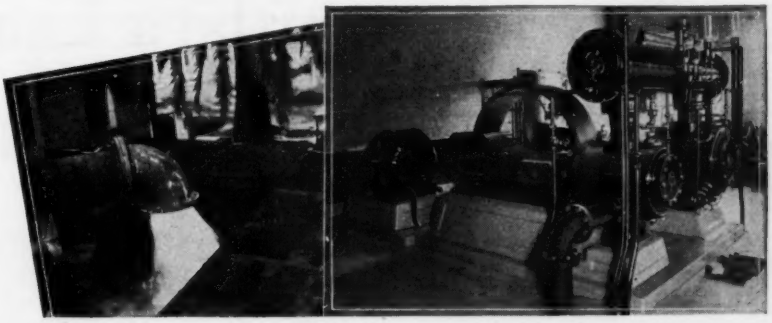

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Measured Total G.P.M.		1600	
Estimated G.P.M. per Well	600		1000
Amperes		125	
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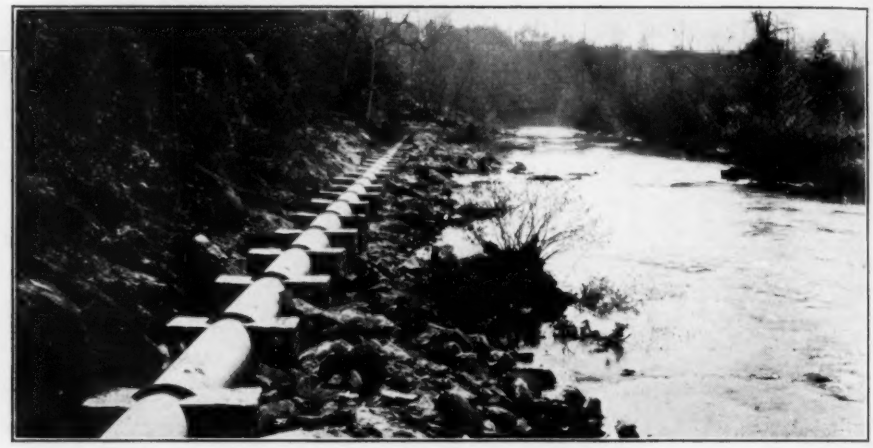

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The Dorr Traction Clarifier in this up-to-date plant, which was designed by Salisbury, Bradshaw and Taylor, is illustrated above. This unit continuously removes the precipitated sludge from the chemically treated water. The use of the Clarifier obviates the necessity of providing excess volume in the settling basins for sludge storage, and eliminates frequent shut downs for cleaning out accumulated sludge.

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Johnson Screens will not choke or clog because the slot is completely undercut.

Permanence is insured by the use of Anaconda Red Brass. This metal will not corrode under the most severe conditions.

No iron is used in the Johnson Screen, which eliminates the danger of electrolytic corrosion.

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for use with threaded fittings

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GENERAL OFFICES: WATERBURY, CONNECTICUT
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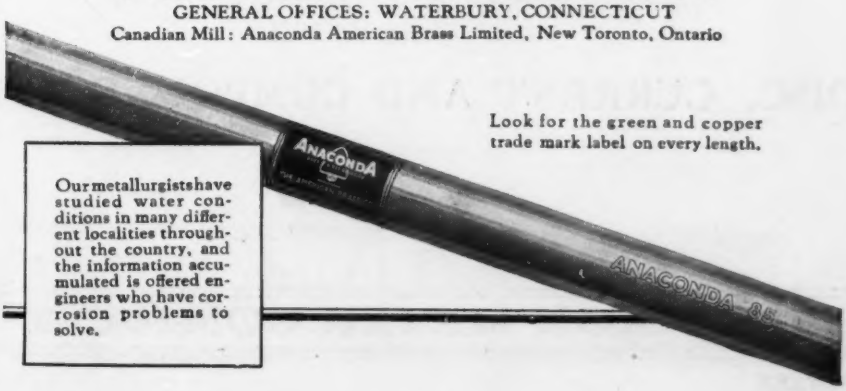
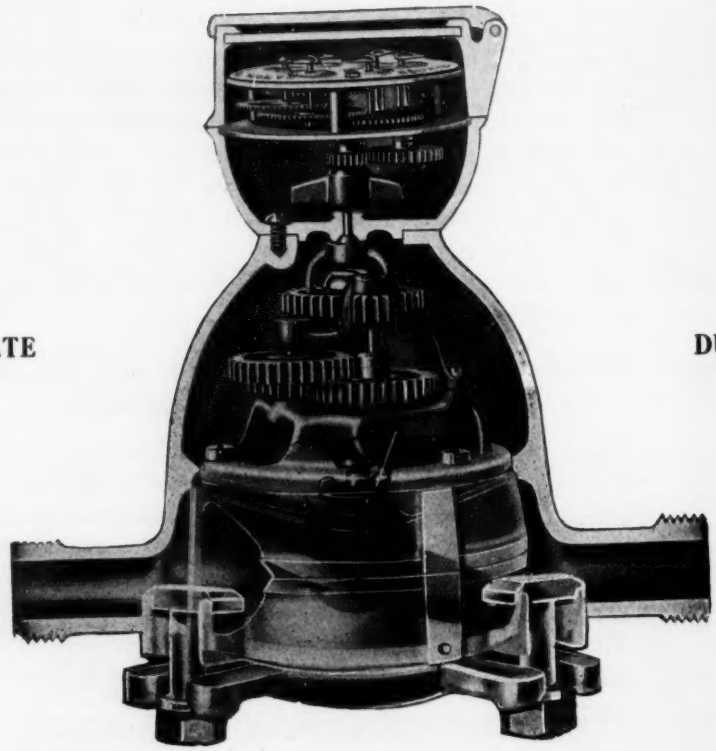


Look for the green and copper trade mark label on every length.

Our metallurgists have studied water conditions in many different localities throughout the country, and the information accumulated is offered engineers who have corrosion problems to solve.

"WATCH DOG" WATER METERS



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Inquiries Solicited

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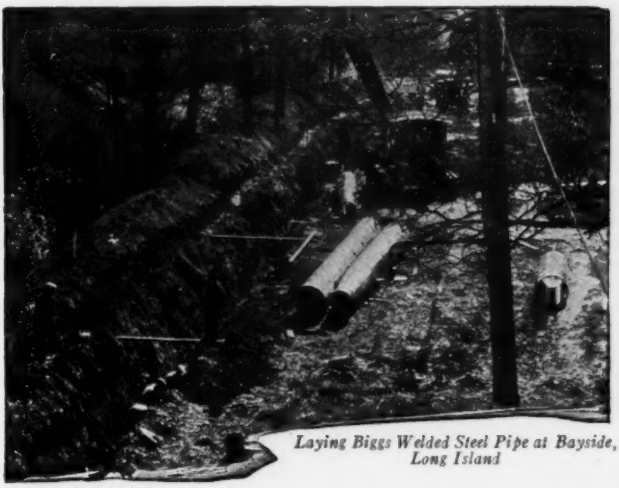

Laying Biggs Welded Steel Pipe at Bayside, Long Island

Steel Pipe is Ideal for Large Conduit Construction

Strength—flexibility—low *first* cost matched by low *service* cost—those are the outstanding advantages of Biggs riveted or welded Steel Pipe.

Into its fabrication go all the skill and experience gained in more than 40 years' contact with water works requirements the country over.

Our engineering department will gladly assist you when you are considering a new project.

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BIGGS Steel Pipe *Riveted and Welded*

The Biggs Boiler Works Co. Akron, Ohio

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Many Water Works men, who knew air lift fifteen or twenty years ago, are unfamiliar with the important developments of this well pumping system.

Today's Sullivan Air Lift is as unlike the air lift systems of the past—as today's aeroplane is unlike the flying machine of 1910. All parts are engineered to work in harmony—to get the most water with the least air—and to make water supply dependable anywhere.

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Not long ago, shallow wells in sand were unreliable. The wells slowed up and stopped. But now, Sullivan Air Lift, by means of the "Air Made" Well, has removed this difficulty. Scores of "Air Made" Wells have already been constructed—and all are successful.

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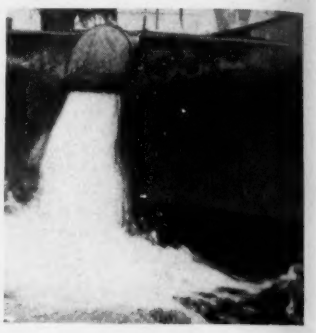
With no moving parts in the well, Sullivan Air Lift is trouble-free. You have no inspecting or repairing of equipment deep in the well—no working barrels or sucker rods to pull—no trouble from mud or sand, crooked wells, or varying water levels.



Low Cost for Water

Trouble-free service, economical Sullivan Air Compressors, and experienced engineering give you a low cost per 1000 g.p.m.

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CLEAN YOUR WATER MAINS

One does not have to be an expert mathematician to figure out that a clogged water main calls for a stronger pressure and that in turn calls for more coal—and literally burning up money. We can show you how to get dollar for dollar value out of every ton of coal. We can show you how to clean the water mains quickly and cheaply. Send us your address—that's all we ask of you.

National Water Main Cleaning Co.

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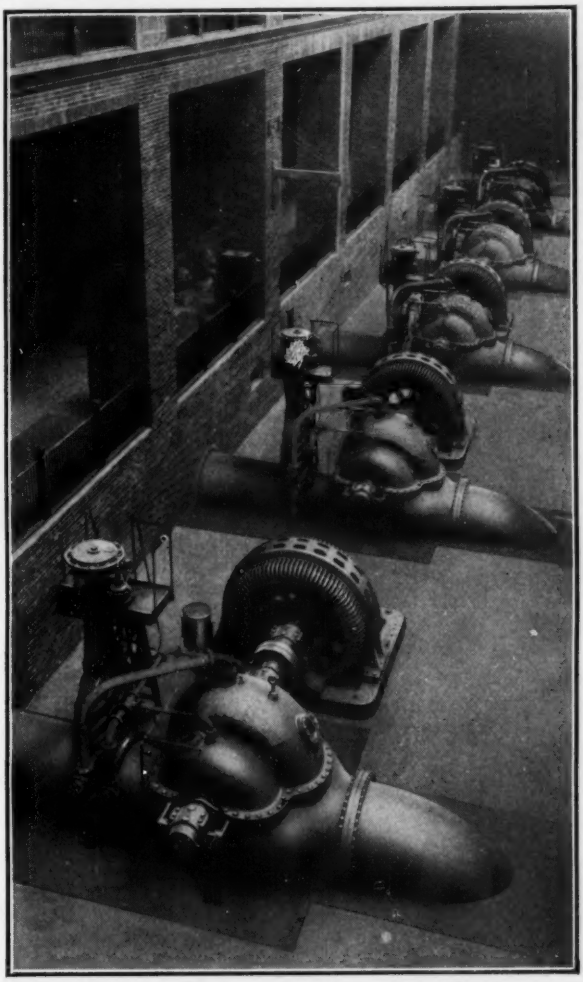

CENTRIFUGAL PUMPING UNITS
SANITARY DISTRICT OF CHICAGO
NORTH SIDE TREATMENT WORKS

These five Allis-Chalmers centrifugal pumping units are installed at the North Side Treatment Works of the Sanitary District of Chicago. Three of the pumps are 48" x 42" and are rated 100 cu. ft. per sec. against a 44-ft. head at 300 r.p.m. They are direct connected to 700-h.p. Allis-Chalmers synchronous motors. The other two pumps are 48" x 48" and are rated 150 cu. ft. per sec.; 44-ft. head; 300-r.p.m.; and are direct connected to 1000 h.p. Allis-Chalmers synchronous motors.

Allis-Chalmers builds a complete line of centrifugal pumps for most any requirements and makes a specialty of combined units consisting of pump and motive power of their own manufacture as the best way to give purchasers a complete unit with both pump and drive properly proportioned. Allis-Chalmers Centrifugal Pumping Units are noted for their uniformly reliable and economical operation.

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MILWAUKEE, WIS. U.S.A.

Health means *Prosperity*

BUY
CHRISTMAS SEALS

they fight for health

The National, State, and Local Tuberculosis Associations of the United States

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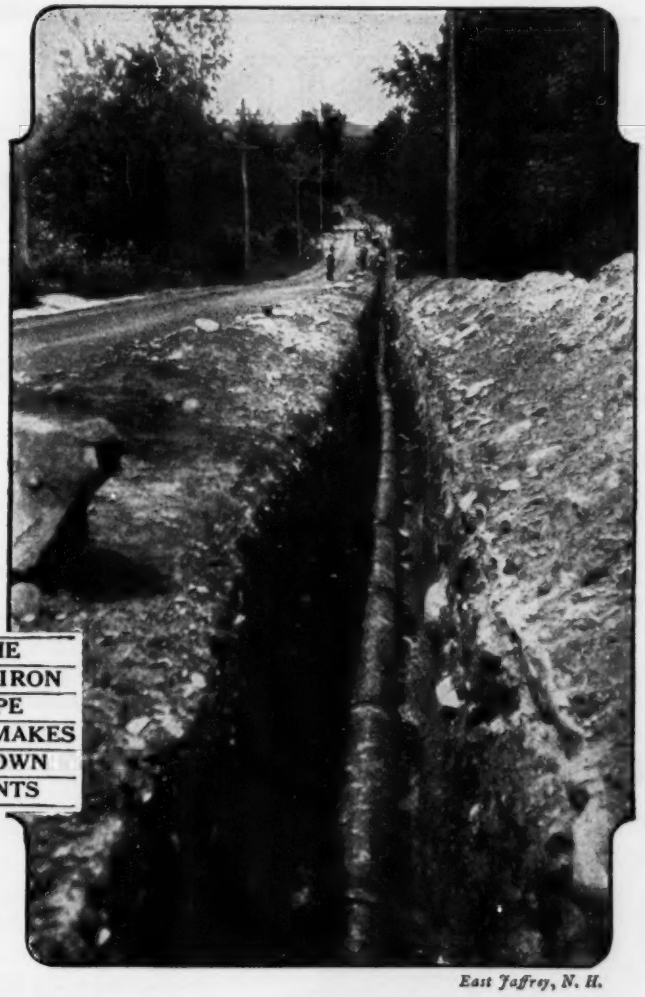
SERVICE BOXES
With *Stay-on* Covers
Just what you have been waiting for . . . Interchangeable with "Buffalo" boxes . . . .
Ask for Monitor Service Box catalog.



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Here's dependable water supply for you!

Dependable because it's 100% cast iron. No hot lead, no cold lead, no lead substitutes, no pouring, no calking. Nothing to work loose, nothing to deteriorate in these flexible, dependable joints—machined iron-to-iron *joints as tight as the wall of the pipe itself.*

Wrenches the only tools. Address nearest office.

UNIVERSAL CAST IRON PIPE
No bell holes to dig: No joints to calk
THE CENTRAL FOUNDRY COMPANY
Subsidiary of The Universal Pipe and Radiator Company
Graybar Building, 420 Lexington Avenue
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VALVES-PIPE FITTINGS-FIRE HYDRANTS

Open or closed—
always dependable

THE men who operate Kennedy Valves know they can always be depended upon to close tightly, release promptly, and respond to every service demand. For half a century and in thousands of plants, Kennedy Valves of every type and size have been demonstrating these characteristics and establishing the Kennedy reputation for thorough reliability.

Kennedy products include gate, globe, angle and check valves for every water works service.

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THE KENNEDY VALVE MFG. CO.
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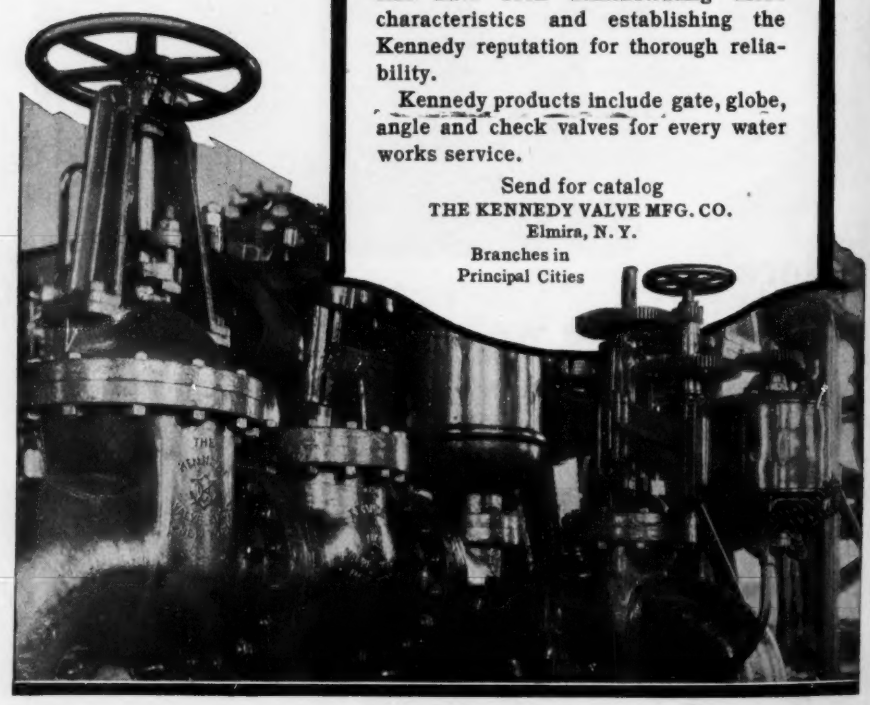

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SERVICE PIPE

Does not depend on water pressure to hold it in shape.

Is not injured by careless handling or back-filling.

Uses standard fittings.

Sixty years use proves it rustless.

Has no harmful effect on any water.

Now standard in dozens of the most progressive cities and towns.

Inexpensive.

CEMENT LINED PIPE CO.
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The Ludlow Valve Mfg. Co.

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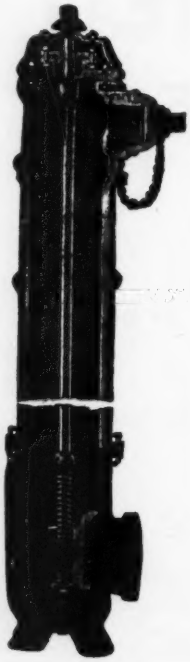

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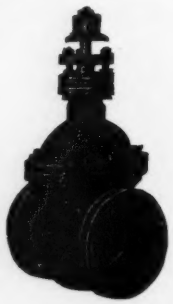
ALL SIZES—EVERY STYLE—ANY PRESSURE



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Simple in Construction

Efficient **Frost-Proof**

"All parts removable without digging up hydrant. Special device prevents street from being flooded should standpipe be broken. Minimum expense to install and maintain."

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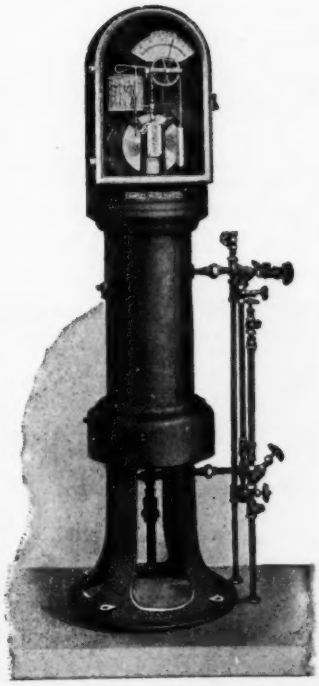
Is Your Water Works Pumping Station Operating Efficiently



Simplex Meter Register

Every up-to-date water works manager holds it essential to know at all times the efficiency of his plant. If pumping, he must know the fuel consumed and the amount of water pumped. Pump counters are unreliable, on account of pump slip varying from zero to 40% in reciprocating pumps, and on centrifugal pumps they are inoperative. If the supply is by gravity, he must know the quantity of water flowing.

Simplex meters provide for either one of these conditions by giving a continuous record of the flow of water. It is simple, rugged, reliable and accurate from the maximum down to 5% of the maximum flow, without material loss of pressure.

Interesting data on the "Simplex Venturi Tube Meter" sent upon request

SIMPLEX VALVE AND METER CO.

Manufacturers of Meters for Water, Sewerage and other liquids, Rate Controllers, Automatic Air Valves, Regulating Valves, and Hydraulic Apparatus of Special Design

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DIFCO

MEDIA FOR THE PRESUMPTIVE TEST

Bacto-Lactose Peptone Bile

An excellent medium for the detection of colon organisms in examinations of potable waters. The bile exerts a partially inhibitory action on non-intestinal bacteria.

Bacto-Brilliant Green Bile

The medium of Muer and Harris in dehydrated form. Anaerobes and non-intestinal lactose fermenting organisms are inhibited. Results are less confusing and identification is rendered more certain.

Bacto-Brilliant Green Bile 2% Special

A very satisfactory medium of low bile content and with a reduced amount of dye. The inhibitory action toward organisms not of the colon group is remarkably definite.

Specify "DIFCO"
THE TRADE NAME OF THE PIONEERS
In the research and development of Bacto-Peptone and Dehydrated Culture Media

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METERS
Disk Meters—furnished with open train or enclosed oil train. Smaller sizes can be fitted with frost protection.
Turbine Velocity Meters. Compound Meters, Hot-Water Meters for boiler-feed lines. Oil Meters.

PUMPS AND PUMPING ENGINES
Steam and power driven, reciprocating and centrifugal, also deep-well.

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Air, Gas and Ammonia-Air Lifts

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Surface, Jet, Barometric and Vacuum Auxiliaries-Steam-Air Ejectors.

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including Diesel-engine driven pumping units.

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Branch Offices in 24 Cities

Help Build up Your Association. Get a New Member

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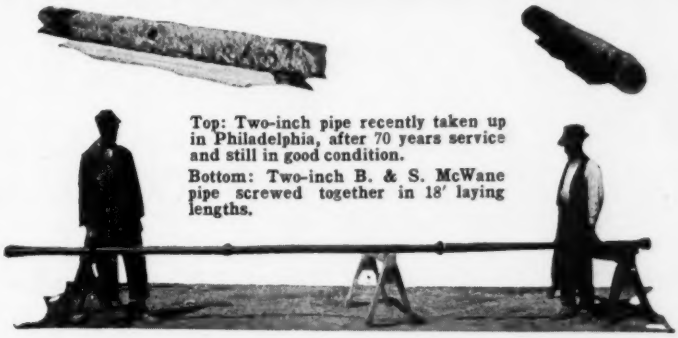
AMERICAN WATER WORKS ASSOCIATION
29 W. 39th St., NEW YORK CITY



Top: Two-inch pipe recently taken up in Philadelphia, after 70 years service and still in good condition.

Bottom: Two-inch B. & S. McWane pipe screwed together in 18′ laying lengths.

Why You Should Say "McWane" When You Buy Small Pipe

McWane small diameter pipe is furnished with or without Precalked joints . . . lengths of 6′, 12′ or 18′ . . . is easily, simply and swiftly laid . . . can be tapped direct under pressure, without fittings.

McWANE is the largest manufacturer of small diameter cast iron pipe in the world . . . the only maker of 1¼″ pipe. McWane leadership in this field is not an accident. Years of research and specialization are back of it.

Small diameter cast iron pipe has been made for a century. But McWane pioneered the manufacture of this product on a commercial scale in the last decade. It is consistent to use cast iron for service lines the same as for your mains.

WRITE FOR ILLUSTRATED LITERATURE

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CAST IRON PIPE

AMERICAN WATER SOFTENER COMPANY

Successor To

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More Than 500 Municipal Filtration Plants Installed

GRAVITY FILTERS
PRESSURE FILTERS

FILTER EQUIPMENT OF EVERY DESCRIPTION

Dry Chemical Feeders	Control Tables
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Fourth and Lehigh Avenues
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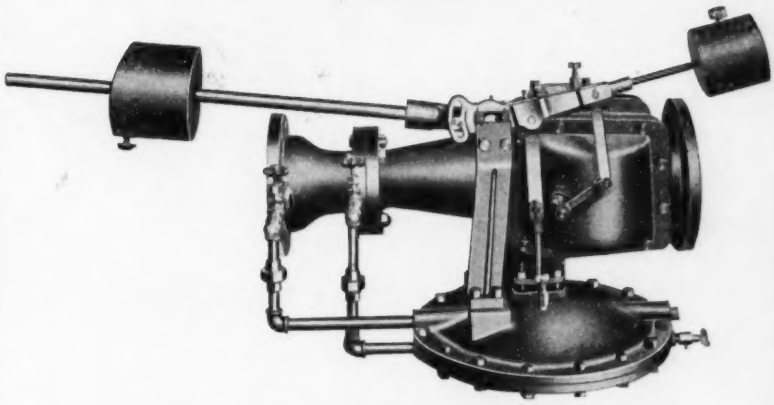
ORIGINATORS OF MECHANICAL FILTRATION

VENTURI
"VENTURI" Registered



Install It and Forget It!

Whether you think about it or not the Venturi Direct-Acting Controller will be right on the job maintaining a constant rate of flow through the filter.

Dependable service of this kind counts, especially in the small and medium size plants where it is impractical to station highly skilled operators or where the operators have plenty to do without continually watching the filters.

Actual installations at various plants over a period of two years have proved so successful that this new Direct-Acting Controller is now offered as the simple, rugged, and powerful controller for which you have been waiting.

Write for New Bulletin 232

BUILDERS IRON FOUNDRY

"Builders of the Venturi for 36 Years"

9 Codding Street **Providence, R. I.**

This

"MAGIC BEAD"

Seals* MONO-CAST *Joints Uniformly!

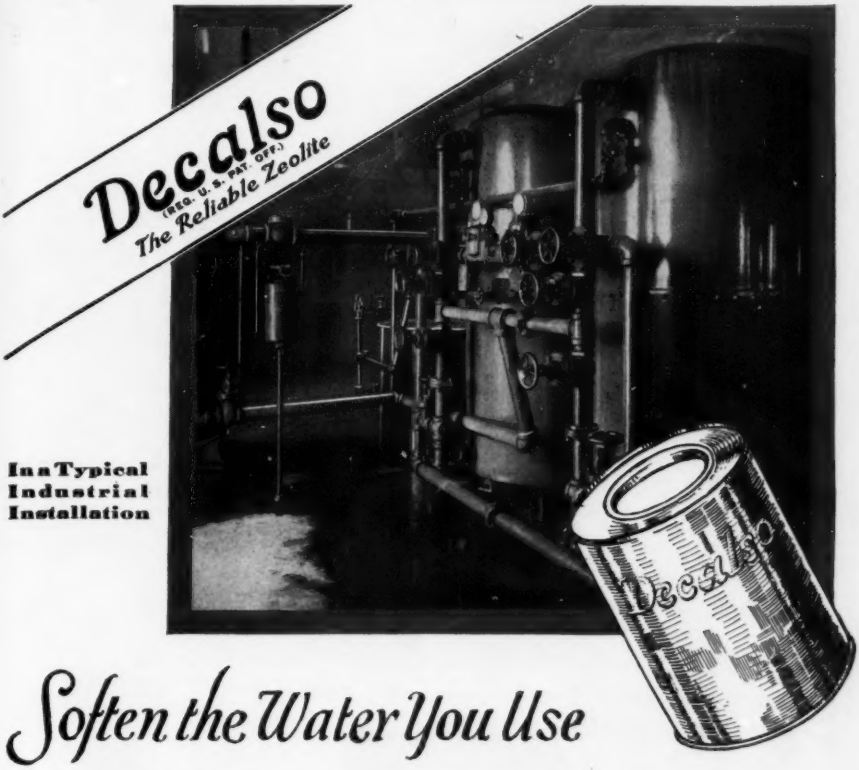
IT'S the bead that decides the future of the joints in your pipe line—because it's the bead that centers the spigot in the bell and anchors it there to stay!

That centering is important, because without it your lead and packing will not be uniformly distributed in the bell.

That anchoring is important because without it your joint might pull out.

In Mono-Cast pipe, the bead is CAST ON the spigot end—increasing the strength of the spigot and insuring it against breakage in transportation or handling in the field.

AMERICAN CAST IRON PIPE COMPANY
BIRMINGHAM, ALABAMA
DISTRICT OFFICES IN PRINCIPAL CITIES



In a Typical Industrial Installation

Soften the Water You Use

"Decalso"—a synthetic zeolite high in base-exchange value, contains the elements which go to make water softening a simple, an economical and a continually dependable operation.

Countless industrial processes demand hardness removal from the water supply. Soft water aids in every domestic task.

"Decalso" produces uniform satisfaction to all. Its steadily increasing demand during the past ten years justifies the term—

"Decalso"—The Reliable Zeolite

Your inquiries relating to Water Softening—its attainment, problems and purposes—are invited.

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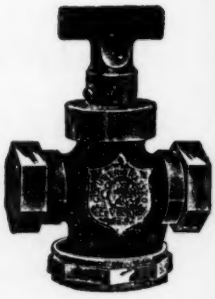
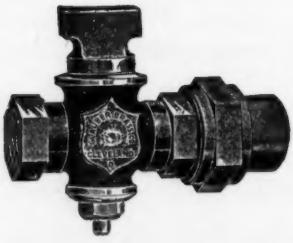
"GLAUBER" BRASS GOODS

NEVER FAIL TO MAKE A GOOD IMPRESSION - ONE THAT LASTS

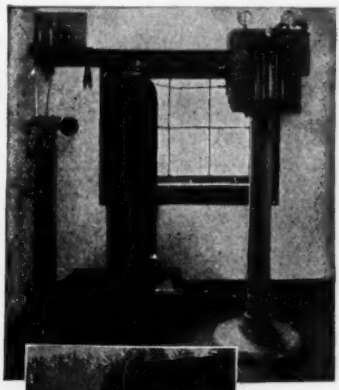




GLAUBER BRASS MFG. CO.

Cleveland, Ohio

All Well Waters —Should Be Chlorinated



The Elizabethtown Water Company, Elizabeth, New Jersey uses the new W & T Chlorinator, type M S P, to sterilize every drop of well water.

PUBLIC HEALTH ENGINEERS are rapidly dissipating the old-fashioned but popular idea that well waters are pure and safe to drink just because they are well waters and come from under-ground sources.

They know that well waters are liable to pollution—that a fissure in the rock or a break in the well casing often permits disease ladened contamination to enter the supposedly pure water—particularly in times of flood.

They know that hundreds of Typhoid Fever Epidemics have been caused by well waters.—They know that the three outstanding typhoid epidemics in recent history—Salem, Ohio — Lansing, Michigan — Santa Anna, California—were all caused by polluted, *unchlorinated* well water.

That is why there is a marked tendency toward the chlorination of all well waters—because a properly chlorinated water cannot cause disease—because chlorination will not change the physical or chemical characteristics of the water in any way — because chlorination costing but one cent per capita per year is the cheapest public health insurance.

"The Only Safe Water is a Sterilized Water"

WALLACE & TIERNAN

COMPANY, INCORPORATED

Manufacturers of Chlorine Control Apparatus

NEWARK , NEW JERSEY

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A clear water-way means greater water capacity

It will be readily understood why LOCK BAR STEEL PIPE has so much more carrying capacity. Obstructions to flow, causing friction, and reducing capacity are practically eliminated. The absence of obstruction and the smooth inner surface further eliminate opportunity for the building up within the pipe of deposits to restrict the pipe area.

EAST JERSEY PIPE COMPANY
7 Dey Street, New York, N. Y.

LOCK-BAR

Before *Closing*

STRONG AS THE PLATE ITSELF

EDSON

DIAPHRAGM
PUMP SPECIALTIES

Hand and Power Outfits

LIGHT PORTABLE TRAILER PUMPS

HEAVY DUTY One or Two Pump UNITS with 3-inch or 4-inch Suction

Insist on GENUINE EDSON Pumps, Suction Hose, Diaphragm with Bead, etc.

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375 Broadway, Boston
142 Ashland Pl. Brooklyn, N. Y.

BELLE ALKALI CO.

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Highest Purity Only
In "White Cap" Cylinders

CAUSTIC SODA

Solid and Flake

BELLE BRAND

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CAST IRON WATER AND GAS

PIPE

By Sand Cast and deLavaud Centrifugal Processes, Fittings and 2" cast iron service pipe and fittings with prepared joint.

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Kansas City Los Angeles
Salt Lake City Dallas

NATIONAL CAST IRON PIPE CO.
Birmingham, Alabama

"Contractors for cleaning water mains.

"A valuable service at a reasonable cost."

General Pipe Cleaning Company

735 Commercial Trust Building
Philadelphia, Pa.

You can always rely on the dependability of Diamond Alkali quality. Once you have determined the chemical reaction of Diamond Alkalies in your process, you have set a formula that can be depended upon to give identical results time after time.

Remember too, that Diamond Alkalies have a nationwide distribution comparable in every way to the quality and uniformity of Diamond Alkalies.

Diamond Alkali Company
Pittsburgh, Penna., *and Everywhere*

THE STANDARD FOR 50 YEARS

Automatic Pressure Control Valves
Feed Water Filters
Portable Fire Hydrants
Hydraulic Engines
Hydraulic Engines—Booster Pumps

ROSS VALVE MFG. CO., INC. TROY, N. Y.

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CAST IRON

WATER & GAS PIPES

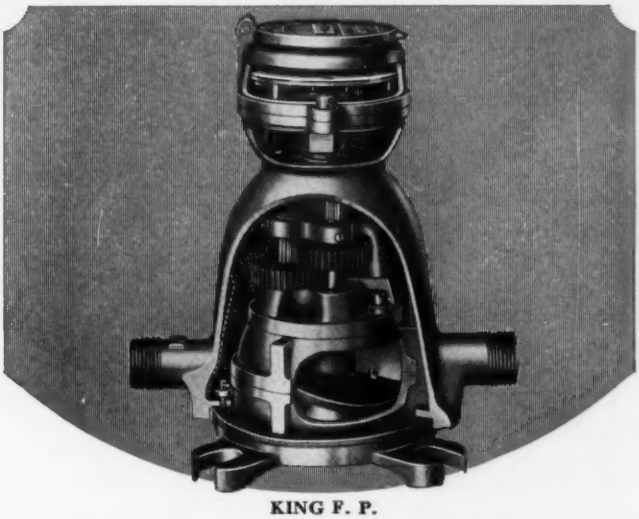
FLANGE PIPE

Special Castings, Fire Hydrants, Valves
General Foundry and Machine Work

WOOLWORTH BUILDING 233 BROADWAY
NEW YORK CITY

Announcing our

Sixtieth Anniversary Meter



KING F. P.

King F. P. (frost protected) Meter is built to overcome every known weakness in frost meter design. Among the new features built into the King F. P., which users of meters will immediately recognize as marked advances, are the position of the thrust roller, an eccentric which locks the disc chamber in place and the use of monel metal pins and lock screws which yield to excessive pressure such as frost.

The thrust roller is located on the outlet side of the disc slot, and is held in place by a monel metal pin which balances the weight perfectly and strengthens this edge of the disc, always heretofore the weakest point. Friction thrust is reduced to a minimum because the roller keeps the control in the center. The roller is made of hard rubber and this perfect insulation eliminates corrosion and galvanic action.

The new method of holding the disc chamber in place employs an eccentric which simplifies installation or removal of the chamber, and eliminates any possibility of the chamber becoming bound. The intermediate gearing is assembled by the use of three slideable monel metal pins held in place on the side by a single lock screw. The same intermediate gearing is used on all sizes of meters and therefore is interchangeable. All bearings are over-size, insulated, adjustable and renewable.

It is with much satisfaction that Union Water Meter Company announces the perfection of the King F. P. Meter on the 60th anniversary of the incorporation of this company.

UNION WATER METER COMPANY

[Incorporated 1868

WORCESTER, MASS.]

New York: 50 Church St. **Philadelphia: 411 Bulletin Bldg.**

Maximum *Protection and Convenience!*

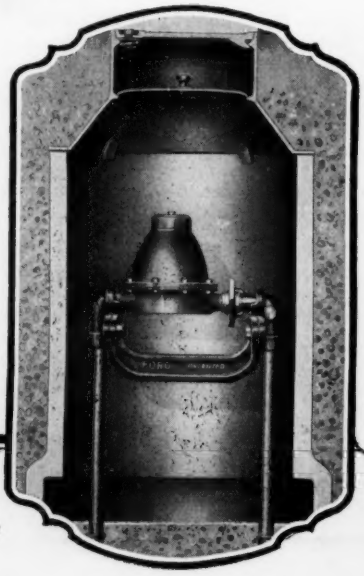
Ford Double Lid Meter Box Covers

WHEREVER there is danger of freezing, the Ford Meter Setting shown at the right is recommended. It affords ample protection against freezing because of the dead air space between the two lids of the cover---just like a "Vacuum Bottle".

At the same time, it prevents tampering or accidental damage For the Ford Worm Lock really locks the lid on so it will stay.

Your water meters are the measure of your income and deserve this protection.

Write Today for Catalog



FORD METER BOX CO.
WABASH, INDIANA U.S.A.

Accessibility Unequalled!

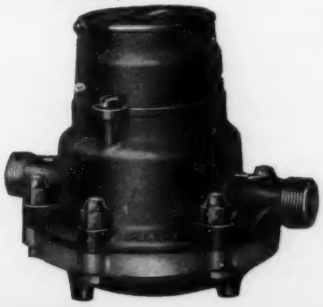
If you can handle a wrench you can open any Niagara or American Water Meter for cleaning or inspection.

A wrench is necessary only to loosen the flange bolts. When the casing is lifted off the internal gears may be lifted from their bearings, the disc chamber taken from its seat and opened, the strainer slipped out or the register tried by turning the gear inside the top casing. There are no parts to stick and require hammering or prying to separate them.

All parts of Niagara and American Water Meters are so carefully machined that they are completely interchangeable. This, with the accessibility means that the least experienced men in your water department can repair, adjust and reassemble a Buffalo built meter reducing the cost of operating your repair department.

Get all the facts on Niagara and American Meters by sending for our new 34 page catalog which we are glad to send without cost or obligation to you.

BUFFALO METER COMPANY
2918 Main St. Buffalo, N. Y.



NIAGARA *and* AMERICAN
IRON CASE BRONZE CASE
Water Meters

NASH METERS

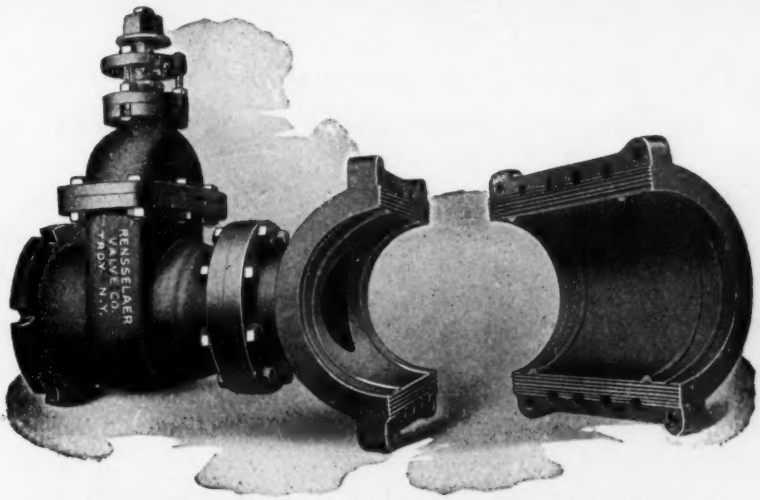
The NASH is one of the best of the numerous disc types on the market. It is an all bronze meter, accurate, carefully made, and up to date in every particular. Straight-reading register, enclosed intermediate, conical, extra slow-moving disc, and the best and most economical of all frost features. Made also in a non-frost model for use in the warmer climates.

Send for fully illustrated circular. Mention whether you use a frost or a non-frost type.

NATIONAL METER COMPANY

299 Broadway

CHICAGO BOSTON CINCINNATI ATLANTA SAN ANTONIO
SAN FRANCISCO LOS ANGELES TORONTO, ONT.



SOME of the POINTS OF SUPERIORITY of RENSSELAER TAPPING SLEEVES

Require ***less lead*** *for Calking*
Easier to center *on pipe* ***before pouring***
Give ***Extra Pipe Protection***
Bolts require ***No Iron Washers***
Each Size *carefully* ***designed for its Working Pressure***
Can be used with all Standard Tapping Machines

Rensselaer Tapping Sleeves are the only Sleeves on the market which are built with two Raised Rings which are a part of the Sleeve Casting itself. These Rings are used as Stops for the Hemp or Jute against which the Lead is poured to make the joint. In other types of Sleeves, without Rings, the Lead, when poured, fills entire space up to point at which cut is made.

The Raised Rings also permit easier centering of Sleeves on Pipe, also permit revolving Sleeve on pipe making it easier to tighten nuts on bolts which connect the two halves of the Sleeve.

The Bolting Flanges on all Sizes of Rensselaer Sleeves are made the full length of the Sleeve, permitting a greater number of bolts to be used back of point calked, giving greater protection to pipe at point where piece is cut out. This is especially important as in some cuts a hole nearly one-half the size of pipe is cut away.

BOOK No. 11 GIVES FURTHER PARTICULARS

RENSSELAER VALVE COMPANY

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NEW YORK, Hudson Terminal Bldg. LOUISVILLE, Starks Bldg.
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PITTSBURGH, Oliver Bldg. NEW ENGLAND, C. L. Brown, Northboro, Mass.

Transactions of the International Conference on Sanitary Engineering, London, 1924

Distributed in the United States by the A. P. H. A.

THE CONTENTS cover a wide variety of subjects, including State Sanitary Administration; Works for the Prevention of Malaria and Yellow Fever; Methods of Disposal of Sewage and Trade Wastes in Various Countries; Treatment of Sludge Arising from the Agitation Processes of Sewage Disposal; Fertilizing Value of Sewage Sludge; Sewerage and the Control of Storm Water; Design of Sedimentation Works; House Sanitation; Refuse Collection and Disposal; National Control of Water Sources. *Price, $4.00*

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370 Seventh Avenue, - - New York City

The Public Health Engineering Section

OF THE

American Public Health Association

IS ONE OF THE ASSOCIATION'S OLDEST AND MOST IMPORTANT DIVISIONS

The Association extends an invitation to every sanitary engineer engaged in the control of the environment to become a member and become affiliated with the section of his profession. Members are entitled to all the services which the Association has to offer, including the American Journal of Public Health. This unique monthly publication gives you the various Committee reports of the Sanitary Engineering Section in addition to original articles and notes on the important developments in your field and also keeps you informed on important topics in all the allied fields of public health. Recent issues of the Journal have contained the following papers of interest to you:

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I am interested in membership in the Association. Please send me an application blank....

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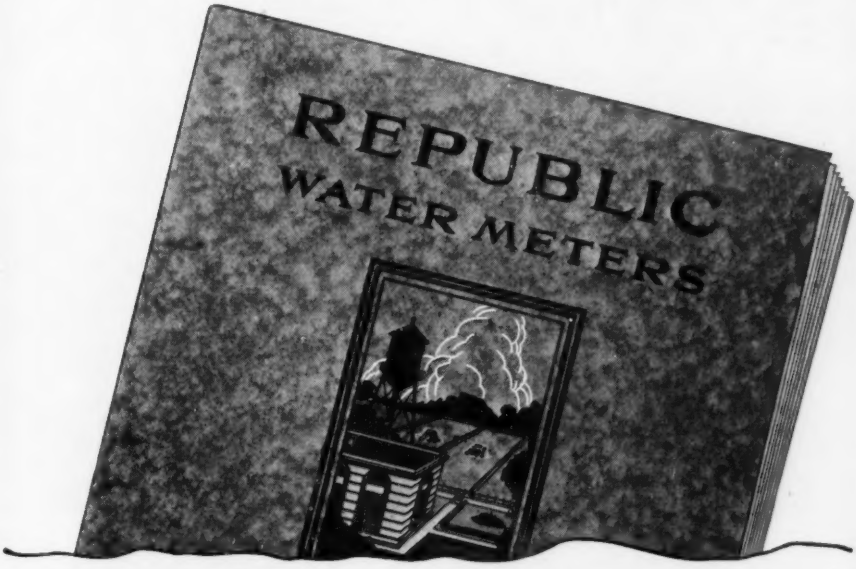
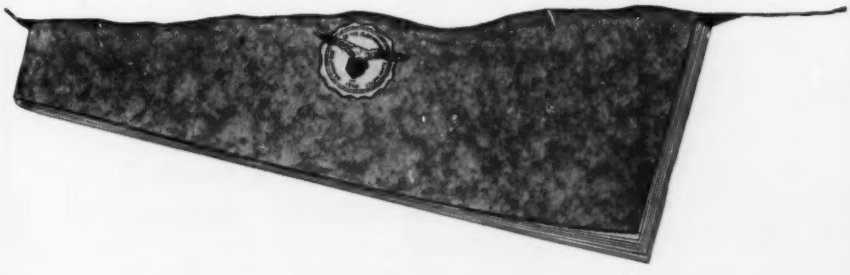


THE New Republic Water Meter Bulletin is now ready for distribution. This bulletin gives a complete survey of the value of meters in water works.

It's yours for the asking. Send for your copy today.



Republic Flow Meters Co.

Factory and General Offices, 2241 Diversey Parkway

CHICAGO, U. S. A.

DOMINION FLOW METERS CO.
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ORIGINATORS OF THE ELECTRICAL FLOW METER

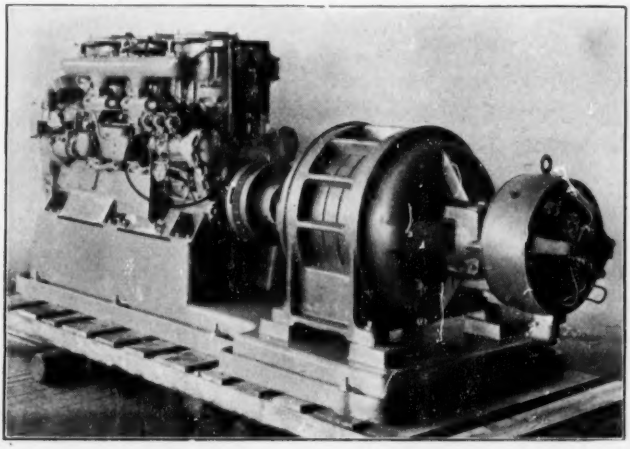
EMERGENCY GENERATOR SETS

QUICK STARTING **ECONOMICAL**

Direct connected, driven by 5¾" bore 6 cylinder 180 H.P. 1200 R.P.M., Sterling engine this 90 K.W. General Electric generator set is low in first cost and inexpensive to operate. You can start it in about 3 seconds. You need never be without power.

Sterling High Duty

Internal Combustion Engines



Many Sterling engines are carrying 18 to 24 hour service for months on a fuel cost of about 3¢ a K.W., hour, when power is almost priceless.

STERLING ENGINE COMPANY **Dept. C-3** **BUFFALO, N. Y.**

10 to 3000 H.P., for standby and peak load. 900–1200–1400 R.P.M.

SULPHATE OF ALUMINA

MANUFACTURED BY

THE JARECKI CHEMICAL CO.

CINCINNATI, OHIO

FOR FULL PARTICULARS APPLY TO

ISAAC WINKLER & BROTHER, Sole Agents

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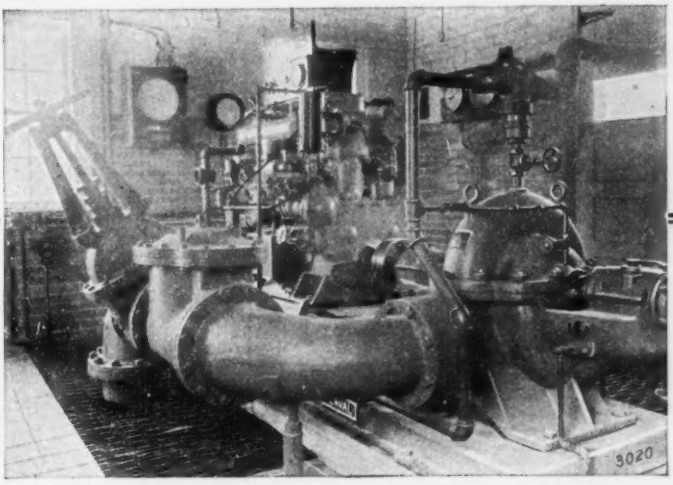
STEEL PIPE P.I.W.

WE ARE PREPARED TO FURNISH AND INSTALL LONG-LIFE PRESSURE PIPE IN ANY QUANTITY AND IN ANY LOCALITY.

PENSTOCK CONSTRUCTION COMPANY

SHARON, PA.

New York **St. Louis** **Tulsa** **Houston**



In Case of Fire

or failure of other equipment

THIS De Laval Centrifugal Pump driven by a gasoline engine is always ready instantly to begin delivering water to the mains of Weymouth, Mass., at the rate of 1800 gal. per min. against 120 ft. total head or, for fire service, 1,000 gal. per min. against 160 ft. head. The pump imposes a low starting torque upon the engine, and is free from the packing and valve troubles of reciprocating pumps. Its high efficiency, which is guaranteed and was verified by test at the Works, insures minimum cost for fuel. Bronze impellers, wearing rings and shaft protecting sleeves prevent erosion or corrosion at important points, while ring oiled bearings in housings separate from the pump casing insure perfect lubrication. The unit has operated in an exceptionally satisfactory manner whenever called upon.

State your pumping requirements and ask for catalog B-94.

De Laval

Steam Turbine Co., Trenton, N.J.

LOCAL OFFICES: Atlanta, Boston, Charlotte, Chicago, Cleveland, Duluth, Havana, Helena, Honolulu, Houston, Indianapolis, Kansas City, Los Angeles, Montreal, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Salt Lake City, San Francisco, Seattle, St. Paul, Spokane, Toronto, Vancouver

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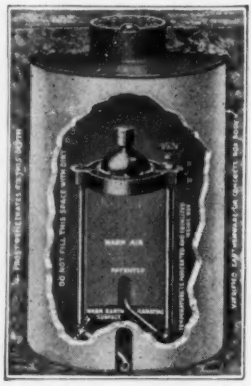

THE CLARK METER BOX

affords absolute protection from damage of any nature.

Perfect Lock

consists of one-piece phosphor bronze bolt engaging on an incline plane on cover to lock and likewise engages on a similar plane on lid to unlock. No rivets, bolts or screws, to rust, preventing operation.

The Only All Bronze Meter Box Lock.

H. W. CLARK COMPANY

Manufacturers of Water Works Equipment

MATTOON, ILLINOIS

Meter Boxes	Meter Coupling Yokes	Valve Boxes
Vitrified Box Bodies	Service Boxes	Valve Housings
Forms for Concrete Bodies	Repair Lids	Meter Testing Machines
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THE WATERPROOF PAINT CO. AQUATITE NORTH HOLLYWOOD CALIF. U.S.A.

SICK, LEAKY RESERVOIRS

Respond to Aquatite doctoring, do not delay, you might have to call an undertaker for your reservoir. Quick deliveries.

Waterproof Paint Company
North Hollywood, Calif.

Trade Mark

MABBS

Reg. U. S. Pat. Off.

You Can Prevent Wear and Cutting of Rods and Plungers by Using

MABBS RAWHIDE PACKING

LASTS LONGER

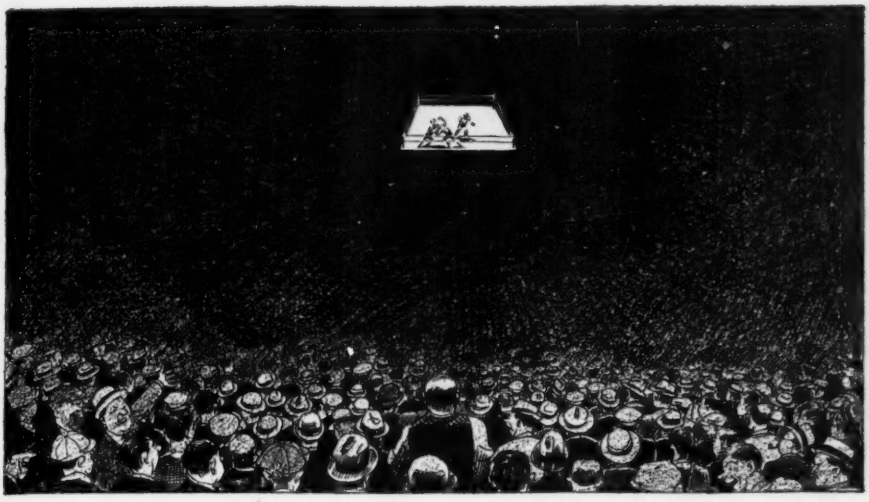
Is Anti-Frictional. Saves Power and Money.

Put up in 5, 10, 15, 25 and 50 lb. pails. Price $3.00 per lb.

We make a specialty of Rawhide Meter Washers which are superior to cork.

MABBS HYDRAULIC PACKING COMPANY

431 S. DEARBORN ST. CHICAGO, ILL.

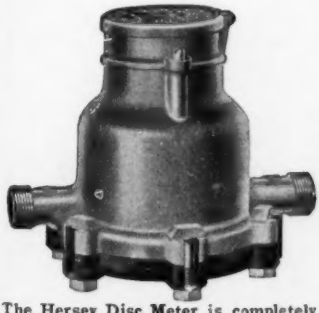


Cash Customers

every drop of water accounted for

WHEN you put Hersey Water Meters on your services, all gate-crashing ceases. Every drop of water pays as it enters. The light, strong, balanced disc piston of a Hersey Water Meter guarantees you accurate performance on all rates of flow, small or large. Hersey sensitivity is not just a flash in the pan, but lasts for years.

The continuous accurate registration of Hersey Water Meters over a period of many years boosts the water department's revenue. The increased revenue more than balances any initial price difference of competitive meters. Hersey Water Meters more than pay for themselves in the long run. Invest now and watch the installment payments flow in with each consumer bill.



The Hersey Disc Meter is completely dipped-tinned, the best known protection against corrosion.

Hersey Manufacturing Company, South Boston, Mass.

HERSEY
WATER METERS

NEW YORK, N. Y., 290 Broadway
PORTLAND, OREGON, 475 Hoyt St.
PHILADELPHIA, PA., 314 Commercial Trust Bldg.
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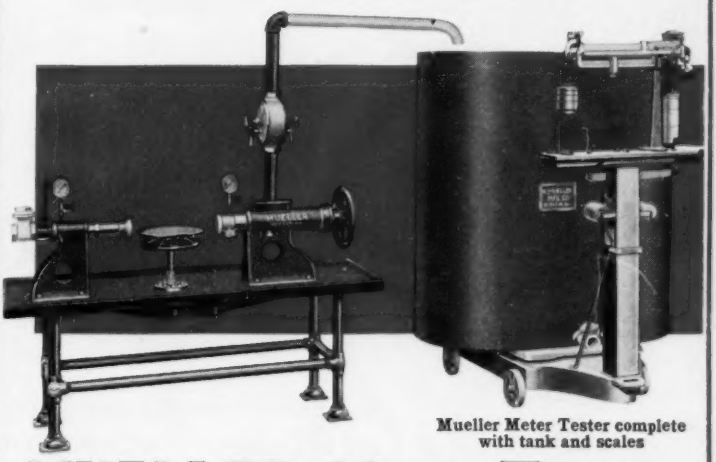
NEW YORK OFFICE

DON'T FORGET

that the Association has headquarters in New York City, where we are ready to be of service to members when possible. When in the City call at the office and make it your headquarters. Have your mail directed there if you have not made hotel reservations, and then come to the office for it, or advise where you wish it sent. Jot the address and telephone number down in your note book NOW, so as to have it when needed.

AMERICAN WATER WORKS ASSOCIATION
29 West 39th Street **Telephone Chickering 3306**

Statistics show that meters under-register oftener than they over-register—



Mueller Meter Tester complete with tank and scales

MUELLER Meter Testers prevent waterworks losses

Here is an important saving possible—through which honestly earned revenues are collected that never could be through any other method.

A Mueller Meter Tester included in your appropriation for 1929 will soon pay for itself out of the savings it makes. All meters should be tested before installation and periodically thereafter.

Simple operation is a prominent characteristic of the Mueller Meter Tester and the workmanship and quality of material in its construction are of the high type always associated with the name of Mueller. It will give a lifetime of service.

A catalog that gives complete information on the Mueller Meter Tester will be mailed on request.

MUELLER CO. (Established 1857), Decatur, Illinois

Branches: New York, Dallas, San Francisco, Los Angeles

Canadian Factory: MUELLER, Limited, Sarnia

MUELLER

ALUMINUM SULPHATE

Among this Company's products are:

SULPHURIC ACID
Oil of Vitriol—Oleum—Mixed Acid—Battery Acid

MURIATIC ACID
(Hydrochloric Acid)

NITRIC ACID

ACETIC ACID
Commercial, Redistilled, Pure and Glacial

And other Heavy Chemicals of Standard Purity

Reagent Chemicals

INSECTICIDES & FUNGICIDES

As Filter Alum this standard product of General Chemical Company meets every requirement of the water works of the nation. The purity and uniformity which commend it for water purification make this Company's product equally preferable in paper mills and with other users. Stocked at and shipped from a country-wide chain of plants and stations.

Have you a handy reference catalog of General Chemical Company products?

Let us send a copy for your use.

GENERAL CHEMICAL COMPANY

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THE NICHOLS CHEMICAL COMPANY, LIMITED, MONTREAL

Merry Christmas and Happy New Year

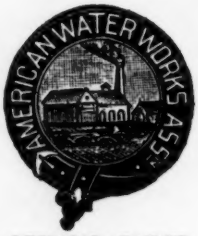
NEPTUNE METER COMPANY

THOMSON METER CORP.

50 East 42nd St. New York City

Pioneers in Meter Progress
Yesterday—TODAY—Tomorrow

BADGES THE AMERICAN WATER WORKS ASSOCIATION



OFFICIAL BADGE

This cut is a facsimile, enlarged, of the official badge or emblem of the association. It is of gold and blue enamel made with a pin, but can be made into a button or watch charm.

The price in solid gold is $5.00 and they can be procured by addressing

AMERICAN WATER WORKS ASSOCIATION
29 West 39th Street, New York, N. Y.

These badges are not to be confused with the usual convention badge, but are for everyday use

Worried by Oily Feed Water?

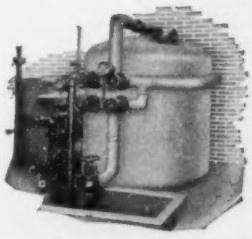
So was this Chief Engineer until Permutit Filters were installed.

A well known plant in Grand Rapids, Michigan operates three boilers with a total rating of 1328 B.H.P. They generally run at 175% rating and their feed water is 85% condensate.

Due to some returns from a reciprocating engine the condensate contained varying amounts of oil, and in spite of the use of oil separators, considerable trouble was always experienced from burned out boiler tubes and forced shut downs. The chief engineer was never certain he could meet a peak load, and it caused him considerable worry.

In January, 1923 a Permutit Oil Removing Plant was installed consisting of two 84" units with a capacity of 12,000 gallons per hour, and at once all trouble from oily feed water ceased. Furthermore, the filters were so efficient that it was possible to use the full returns from the reciprocating engine, thus saving valuable condensate that had previously been discharged to waste. A letter from the manager states in part:

"We had considerable trouble with our boilers, losing one old H. R. T. boiler, and replacing a number of tubes in our water tube boilers. Since installing the oil removing system we have used the condensation from the Hamilton engine, and after getting the oil cleaned out from our boilers and economizers, have found absolutely no trace of oil."



Whether your plant is large or small it will pay you to know about Permutit Oil Removing Filters. Send for our free booklet, "Saving Fuel and Repairs with Oil Free Feed Water." No obligations, write today.

The Permutit Company

Apparatus for Removing Impurities from Water

MAIN OFFICE: 440 FOURTH AVE., NEW YORK—BRANCH OFFICES IN ALL PRINCIPAL CITIES

HELP BUILD UP YOUR ASSOCIATION BY

BRINGING IN A NEW MEMBER

SEND FOR
APPLICATION BLANKS

AMERICAN WATER WORKS ASSOCIATION

29 WEST 39TH STREET, NEW YORK CITY

BADGER METER MANUFACTURING COMPANY

MILWAUKEE WISCONSIN

BRANCH OFFICES:
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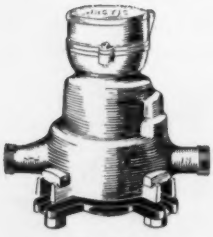
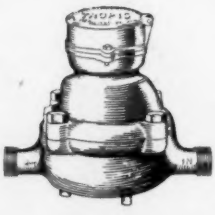
111 West Washington Street, Chicago, Ill.
Atlantic Street Terminal, Pier A, Seattle, Wash.

Sandblasted-

EVERY precaution is taken to assure our users high grade perfect castings. In addition to the tumbling barrel method of cleaning, every casting used in the manufacture of Pittsburgh Equitable Meter Company water meters, is cleaned by the sand blasting and acid bath process. Clean castings are essential to the efficient water meter.



ARCTIC



TROPIC

PITTSBURGH EQUITABLE METER COMPANY

PITTSBURGH, PA.

BRANCH OFFICES
New York, New York.
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Seattle, Washington.
Columbia, S. Carolina.
Salt Lake City, Utah.
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LaMotte Roulette Comparator

Patent Applied For

This Apparatus Makes it Easy to Use Hydrogen Ion Control.

In water purification work, as in many process industries, the application of Hydrogen Ion Control is greatly simplified by use of the LaMotte Roulette Comparator. Anyone who can read and match colors can readily be taught to use this simple, compact outfit, so that routine pH determinations may be carried out by any intelligent workman. Reliable results are assured at all times by LaMotte Permanent Color Standards which bear our unqualified guarantee.

Price $60.00 f.o.b. Baltimore

LaMotte Chemical Products Co.

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LaMotte

Write for a complimentary copy of "The A B C of Hydrogen Ion Control"

TRADE **"LEADITE"** MARK

Registered U. S. Pat. Office

Laid 10 miles of water main—and satisfactory in every particular!

—said a waterworks engineer of national reputation, referring to this installation

Here is the story:—

THE Second Taxing District, South Norwalk, Connecticut, U. S. A., has just completed the installation of approximately ten miles of cast iron bell and spigot water mains, varying in size from 6" to 18". The work included the placing of about fifty cutting-in-tees on existing piping and their connection to new work.

Leadite was selected for jointing material after receiving competitive bids for laying with lead.

The total amount of the successful bids for all work, excepting the furnishing of the cast iron pipe, specials and valves, was as follows:

Lead Joints	$155,631
LEADITE Joints	142,535
Difference	$ 13,096
Saving in favor of LEADITE	8.4%

The work was performed by contractors experienced in the use of this material and was satisfactory in every particular.

Specifications required that after laying, the pipe should be tested for leakage under water pressures varying from 40 pounds to 115 pounds per square inch, and that the leakage should not exceed two gallons per 24 hours per linear foot of joint. The results of the tests were well within this limit.

This work was under the direction and supervision of Mr. Nicholas S. Hill, Jr., Consulting Engineer, 112 East 19th Street, New York, N. Y., U. S. A.

Leadite is used extensively by thousands of water works engineers, superintendents and contractors with excellent results.

Specify and use **LEADITE** It saves at least 75%

Be sure it is **LEADITE** and accept no imitations

The pioneer self-caulking material for c. i. pipe. Tested and used for over 30 years.

THE LEADITE COMPANY

Land Title Building **Philadelphia, Pa.**

NO CAULKING